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(54) 【発明の名称】 芳香族化合物の製造方法

(57) 【要約】

【課題】 ハロゲン含有芳香族化合物から反応器の腐食なく、高収率で加水分解および脱炭酸させ、対応するハロゲン含有芳香族化合物を製造する方法を提供する。

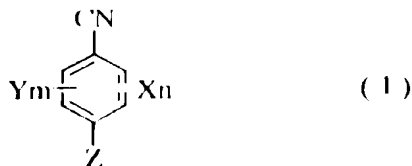
【解決手段】 芳香族シアノ化合物を酸性物質の存在下に加水分解および脱炭酸させて対応する芳香族化合物を製造するにあたり、該加水分解および脱炭酸反応を多段階で行うことを特徴とする芳香族化合物の製造方法である。特に芳香族シアノ化合物がハロゲンを含む場合に、副生するハロゲン化水素によって反応器が腐食するのを有効に防止でき、同時に高収率で目的物を製造することができる。

【特許請求の範囲】

【請求項 1】 一般式(1)で表される芳香族化合物を酸性物質の存在下に加水分解および脱炭酸させる。

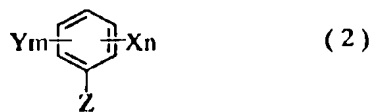
一般式(2)で表される芳香族化合物を製造するにあたり、該加水分解および脱炭酸反応を多段階で行い、得られた該芳香族化合物を水との共沸蒸留によって反応液から回収することを特徴とする芳香族化合物の製造方法。

【化 1】



(式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。))で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1 ≤ m + n ≤ 4である。)

【化 2】



(式中の記号は一般式(1)と同じ。)

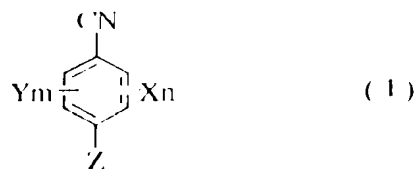
【請求項 2】 該前段階反応の一般式(1)で表される芳香族シアノ化合物の転化率を40モル%以上、かつ一般式(2)で表される芳香族化合物の生成量を80モル%以下とすることを特徴とする、請求項1記載の芳香族化合物の製造方法。

【請求項 3】 該多段階のうち前段階と後段階において、酸性物質の濃度を下げることおよび／または反応温度を上げることの条件を変えて反応を行なうことを特徴とする、請求項1記載の芳香族化合物の製造方法。

【請求項 4】 該加水分解および脱炭酸反応を、硫酸の存在下にガラス製あるいはガラスライニング製反応器中で行う請求項1に記載の芳香族化合物の製造方法。

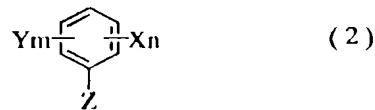
【請求項 5】 一般式(1)で表される芳香族シアノ化合物を水性媒体の存在下に加水分解および脱炭酸させて一般式(2)で表される芳香族化合物を生成させた後、得られた該芳香族化合物を水との共沸蒸留によって反応液から回収することを特徴とする、芳香族化合物の製造方法。

【化 3】



(式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。))で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1 ≤ m + n ≤ 4である。)

【化 4】



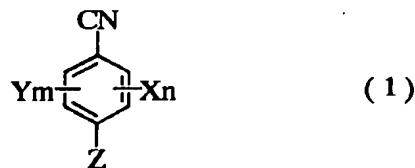
(式中の記号は一般式(1)と同じ。)

【請求項 6】 該式(2)で表される芳香族化合物の収率が、85モル%以上であることを特徴とする、請求項5記載の芳香族化合物の製造方法。

【請求項 7】 該水性媒体が、アルカリ性物質を含んでいることを特徴とする、請求項5記載の芳香族化合物の製造方法。

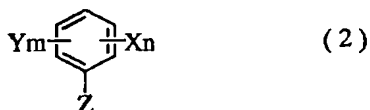
【請求項 8】 一般式(1)で表される芳香族シアノ化合物を酸性物質の存在下に加水分解および脱炭酸させて一般式(2)で表される芳香族化合物を製造するにあたり、該加水分解および脱炭酸反応を多段階で行い、得られた該芳香族化合物を水との共沸蒸留によって反応液から回収することを特徴とする、芳香族化合物の製造方法。

【化 5】



(式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。))で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1 ≤ m + n ≤ 4である。)

【化 6】



(式中の記号は一般式 (1) と同じ。)

【請求項 9】 該多段階のうち前段階と後段階において、該前段階反応において一般式 (1) で表される芳香族シアノ化合物を濃度 8 0 ~ 9 8 質量%の酸性物質条件下でおこない、次いで該後段階反応で上記酸性物質濃度を 5 ~ 5 0 質量%低下させ、および/または反応温度を 5 ~ 3 0 °C 上げた条件下で行なうことを特徴とする、請求項 8 記載の芳香族化合物の製造方法。

【請求項 1 0】 該前記反応液における式 (2) で表される芳香族化合物の収率が、8 5 モル%以上であることを特徴とする、請求項 8 記載の芳香族化合物の製造方法。

【発明の詳細な説明】

【0 0 0 1】

【発明の属する技術分野】 本発明は、ハロゲン含有芳香族化合物の製造方法に関し、ハロゲン含有芳香族シアノ化合物を原料として、反応器の腐食を生ずることなく加水分解および脱炭酸反応を行い、高収率で目的物たる対応する芳香族化合物を製造する方法に関する。

【0 0 0 2】

【従来の技術】 テトラハロゲノアニリンの中には、医薬品や農薬の中間原料として使用される重要な化合物が含まれる。たとえば、2, 3, 5, 6-テトラフルオロアニリンの製造方法は、特開平 6-2 1 1 7 5 6 号公報、特開平 8-2 6 8 9 7 9 号公報などに記載されている。特開平 6-2 1 1 7 5 6 号公報に記載の方法は、原料としてペンタフルオロ安息香酸を用い、これをアンモニアと水性媒体中で反応させてアミノ化・脱炭酸を行い 2, 3, 5, 6-テトラフルオロアニリンを得るというものである。原料であるペンタフルオロ安息香酸は、ペンタフルオロベンズニトリルを硫酸水溶液中で加水分解して得る事ができ、反応水溶液中にはペンタフルオロ安息香酸のほかに過剰の硫酸や反応生成物の硫酸アンモニウムが混入しているが、ペンタフルオロ安息香酸を水洗することなくそのまま 2, 3, 5, 6-テトラフルオロアニリンの製造反応に供することができるとしている。

【0 0 0 3】 また、特開平 8-2 6 8 9 7 9 号公報に記載の方法は、原料として 4-アミノ-2, 3, 5, 6-テトラフルオロベンズニトリルを用い、これを水とともに硫酸水溶液に添加し、加水分解および脱炭酸反応によって生成する 2, 3, 5, 6-テトラフルオロアニリンを水との共沸蒸留により留出させながら加水分解および脱炭酸反応を進め、2, 3, 5, 6-テトラフルオロアニリンを得るというものである。副反応によって発生するフッ酸がステンレスやガラスライニングの反応器を腐食するため、生成した 2, 3, 5, 6-テトラフルオロ

アニリンを直ちに水と共沸させて留出させると、反応器内の硫酸濃度を一定に保持するために水を供給し、結果として反応器の腐食を抑制し、高収率で 2, 3, 5, 6-テトラフルオロアニリンを得る方法である。

【0 0 0 4】

【発明が解決しようとする課題】 一般に、反応に硫酸などを使用する場合、鉄製あるいはステンレス鋼製反応器では腐食が起こるので、ガラス製あるいはガラスライニング製反応器が用いられる。前記特開平 8-2 6 8 9 7 9 号公報に記載の方法の場合は、反応器の腐食を防止する方法であるが、低純度の 4-アミノ-2, 3, 5, 6-テトラフルオロベンズニトリルを用いる場合には、反応器の腐食が認められる。その一方、不純物の除去操作を行なうと、反応器の腐食は防止できるが工程が増加し、不利である。

【0 0 0 5】 また、前記特開平 8-2 6 8 9 7 9 号公報において実施例で得られた 2, 3, 5, 6-テトラフルオロアニリンは、収率が 8 2. 5 % であり、更なる収率の向上が望まれる。

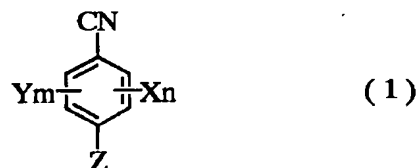
【0 0 0 6】

【課題を解決するための手段】 本発明者は、ハロゲン含有芳香族シアノ化合物を加水分解および脱炭酸して得られる対応する芳香族アミノ化合物の合成経路および不純物の副生について詳細に検討した結果、加水分解および脱炭酸反応を、異なる条件の 2 段階に分けて行なうと、不純物の発生が低下し、収率が向上し、かつ反応器の腐食も防止できることを見出した。また、目的物を反応系から留出させる時期についてさらに詳細に検討した結果、水性媒体の存在下に加水分解および脱炭酸反応を行い、芳香族アミノ化合物を生成させたあとに、当該芳香族アミノ化合物を水と共沸蒸留して留出させると反応器の腐食を防止しつつ収率よく目的物である芳香族アミノ化合物が得られることも見出し、本発明を完成させた。すなわち、本発明は、以下の (1) ~ (3) を提供するものである。

【0 0 0 7】 (1) 一般式 (1) で表される芳香族シアノ化合物を酸性物質の存在下に加水分解および脱炭酸させて一般式 (2) で表される芳香族化合物を製造するにあたり、該加水分解および脱炭酸反応を多段階で行うことを特徴とする芳香族化合物の製造方法。

【0 0 0 8】

【化 7】

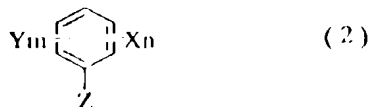


【0 0 0 9】 (式中、X はハロゲン原子であり、Y はシアノ基、ニトロ基またはカルボキシル基であり、Z は一

【0010】（式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。)で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1≤m+n≤4である。)

【0010】

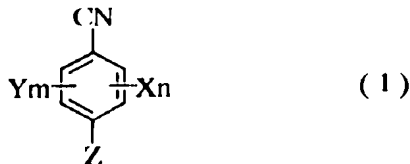
【化8】



【0011】（式中の記号は一般式(1)と同じ。）
 (2) 一般式(1)で表される芳香族シアノ化合物を水性媒体の存在下に加水分解および脱炭酸させて一般式(2)で表される芳香族化合物を生成させた後、得られた該芳香族化合物を水との共沸蒸留によって反応液から回収することを特徴とする、芳香族化合物の製造方法。

【0012】

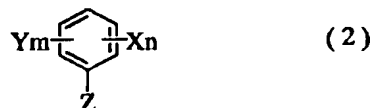
【化9】



【0013】（式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。)で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1≤m+n≤4である。)

【0014】

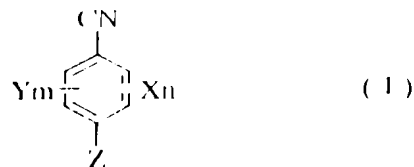
【化10】



【0015】（式中の記号は一般式(1)と同じ。）
 (3) 一般式(1)で表される芳香族シアノ化合物を酸性物質の存在下に加水分解および脱炭酸させて一般式(2)で表される芳香族化合物を製造するにあたり、該加水分解および脱炭酸反応を多段階で行い、得られた該芳香族化合物を水との共沸蒸留によって反応液から回収することを特徴とする、芳香族化合物の製造方法。

【0016】

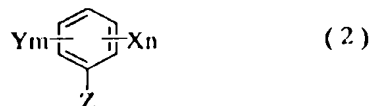
【化11】



【0017】（式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。)で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1≤m+n≤4である。)

【0018】

【化12】



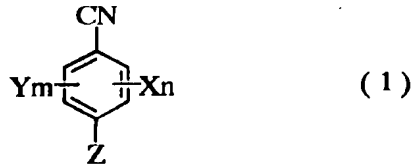
【0019】（式中の記号は一般式(1)と同じ。）

【0020】

【発明の実施の形態】本発明の第一は、一般式(1)で表される芳香族シアノ化合物を酸性物質の存在下に加水分解および脱炭酸させて一般式(2)で表される芳香族化合物を製造するにあり、該加水分解および脱炭酸反応を多段階で行うことを特徴とする芳香族化合物の製造方法である。

【0021】

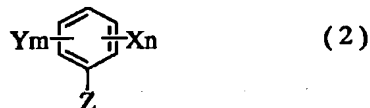
【化13】



【0022】（式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)(ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1～4の直鎖または分岐したアルキル基である。)で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1≤m+n≤4である。)

【0023】

【化14】



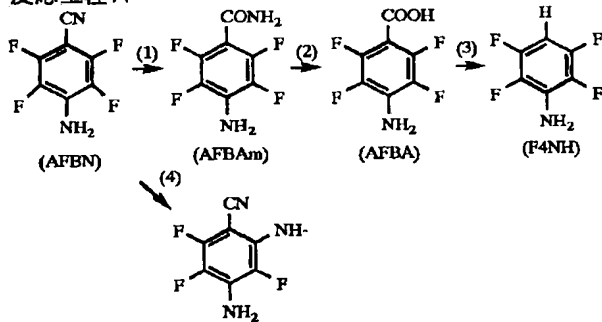
【0024】(式中の記号は一般式(1)と同じ。)
例えば、一般式(1)で表される芳香族シアノ化合物を含む原料として低純度の4-アミノ-2,3,5,6-テトラフルオロベンゾニトリルを用いると、フッ化水素による反応器の腐食が発生する場合がある。この原因について検討したところ、原料中に含まれる不純物、例えば、2-アミノ-3,4,5,6-テトラフルオロベンゾニトリルに起因すると考えられ、腐食との関係を検討したところ、以下の知見を得た。

【0025】まず、4-アミノ-2,3,5,6-テトラフルオロベンゾニトリル(AFBN)を硫酸を用いて加水分解・脱炭酸させて2,3,5,6-テトラフルオロアニリン(F4NH)を製造する場合、その加水分解および脱炭酸反応は次のような、工程(1)～(3)からなる反応工程Aを経て進行すると考えられる。

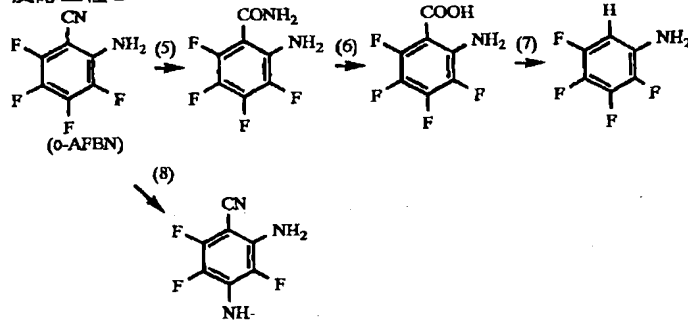
【0026】

【化15】

反応工程A



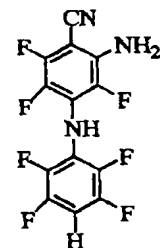
反応工程B



【0029】工程(8)を経る場合には、例えば、目的物である2,3,5,6-テトラフルオロアニリン(F4NH)のアミノ基と2-アミノ-3,4,5,6-テトラフルオロベンゾニトリル(o-AFBN)の4位のフッ素原子との置換反応により、下記に示す式(3)で示される化合物が生成し、同時にフッ化水素が副生する。

【0030】

【化17】



(3)

【0031】一方、原料4-アミノ-2,3,5,6-テトラフルオロベンゾニトリル(AFBN)が、反応工程Aの副反応として工程(4)を経ると、下記に示す式(4)で示される化合物が生成し、同時にフッ化水素が

【0027】しかし、純度が低い原料化合物を使用する場合には、上記反応の過程でフッ化水素が副生して、ガラス製あるいはガラスライニング製反応器の腐食が起こり易くなる。この原料化合物に含まれる不純物として2-アミノ-3,4,5,6-テトラフルオロベンゾニトリル(o-AFBN)に着目した。該化合物が含まれていると、加水分解および脱炭酸反応の過程で、次のような工程(5)～(7)からなる反応工程Bが行なわれ、または工程(8)を経る反応が行なわれる。

【0028】

【化16】

式(1)で表される芳香族シアノ化合物を加水分解・脱炭酸して一般式(2)で表される芳香族化合物を生成し得るものであればいずれも使用することができる。酸性物質の代表例としては、硫酸、塩酸、硝酸などの無機酸、あるいは酢酸、プロピオン酸、酪酸などの有機酸を挙げることができる。なかでも、硫酸が好適に用いられる。該芳香族シアノ化合物のアミノ基が硫酸塩を形成するためフッ素原子に対する反応性が低下すること、および上記工程(4)や工程(8)の反応よりも工程(1)および工程(5)の反応を早く進行させることができるからである。

【0042】本発明の製造方法においては、反応器としては、鉄製、ステンレス鋼製などの一般に用いられている反応器を用いてもよいが、酸性物質、もしくは反応の過程で生成する副生物などにより腐食が起こり易いときには、例えば、硫酸を使用するときには、ガラス製あるいはガラスライニング製反応器を用いるのがよい。そのほか、フッ素系樹脂などの耐腐食性材料で被覆した反応器を用いてもよい。通常、コストなどを考慮して、ガラス製あるいはガラスライニング製反応器を用いるのが一般的である。

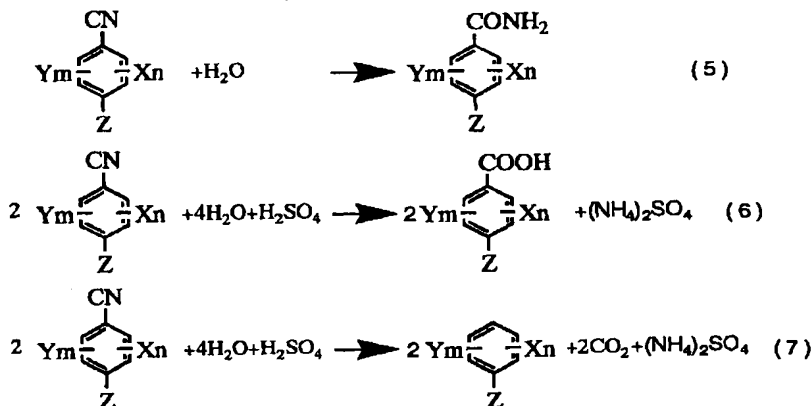
【0043】酸性物質は、原料芳香族シアノ化合物の加水分解および脱炭酸反応が進行するに足る水とともに使用するが、酸性物質は、高濃度であることが好ましい。高濃度の酸性物質を使用すると純度が低く、不純物を含む原料を使用しても、反応器の腐食を引き起こすことなく、目的とする2, 3, 5, 6-テトラハロゲノアニリンを高収率で得ることができるからである。例え

ば、比較的高濃度の硫酸水溶液を用いて加水分解および脱炭酸反応を行うと、不純物である2-アミノ-3, 4, 5, 6-テトラハロゲノベンズニトリルのシアノ基が速やかに加水分解されて、シアノ基の電子吸引性が低下し、その結果、シアノ基に対してパラ位の置換されやすいフッ素原子が置換反応を受けにくくなるためと考えられる。また、フッ素原子に対して求核置換反応を起こすアミノ基が硫酸と塩を形成する結果、フッ素原子に対する求核置換の反応性が低下するためと考えられる。本発明は、このような理論的考察によって制約を受けるものではないが、使用する酸性物質は、水溶液として使用することが好ましく、該水溶液の酸性物質濃度は、80~98質量%、好ましくは82~96質量%、より好ましくは84~94質量%である。この範囲で上記特性が得られるからである。なお、酸性物質の濃度とは、仕込み時または反応中の酸性物質濃度である。

【0044】すなわち、酸性物質として、例えば硫酸水溶液を使用した場合、原料化合物を反応液に添加すると下記の化学式(5)、(6)、(7)のように反応が進行するため、水および硫酸が消費され、酸性物質濃度は変化する。そこで、反応液中の生成物の生成割合を、例えば液体クロマトグラフィーなどの分析によって、求め、下記の化学式をもとに、反応液中に残存する水および硫酸量を算出して求めた硫酸濃度が、本願における酸性物質濃度である。

【0045】

【化19】



【0046】本発明は、加水分解および脱炭酸反応を多段階で行うことを特徴とするものであるが、本発明の芳香族化合物の製造方法では、一般式(1)で表される芳香族シアノ化合物のCN基を加水分解してCOOH基とする加水分解工程と、該COOH基を水素原子にする脱炭酸反応とが並行して進行する。従って、本発明における「加水分解および脱炭酸反応」とは、加水分解と脱炭酸反応とを一連の反応と捉えて表現したものである。このため、「加水分解および脱炭酸反応を多段階」で行なうとは、上記一連の反応のある状態までを前段階とし、

その後、反応を終了させて目的物を得る後段階に分けることを意味する。所定の段階まで加水分解反応を行なった後、加水分解反応生成物を分離することなく異なる条件で引き続き脱炭酸反応を行い反応を完結することが好ましい。このように、該加水分解および脱炭酸反応を多段階で行うと、前段階を部分的加水分解を行なう段階とすれば、該前段階でシアノ基に対してパラ位またはオルソ位に存在する置換基の反応性を低下させて、副生物の生成を抑制でき、特に原料芳香族シアノ化合物に、Zがハロゲン原子である不純物が含まれている場合には、ハ

質として硫酸を使用し、2, 3, 5, 6-テトラフルオロアニリンを製造する場合について説明する。

【0054】本発明においては、加水分解および脱炭酸反応は、通常、ガラス製あるいはガラスライニング製反応器に硫酸の水溶液を仕込み、これに原料の4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルを添加して行う。原料の添加は一度に反応器に仕込んでも、逐次的または連続的に仕込んでよいが、原料を逐次的に添加すると反応の選択率が高く、反応器の腐食が起こらず好ましい。原料を逐次的に添加する場合、添加速度は適宜選択できるが、硫酸水溶液100質量部に対し、1時間当たり0.1~20質量部、好ましくは1~10質量部で添加するのがよい。なお、原料の4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルの添加は前段反応の終了前に完了させるのが望ましい。

【0055】硫酸は、4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルの加水分解および脱炭酸反応が進行するに十分な量の水とともに使用する。通常、硫酸水溶液として使用するが、その硫酸水溶液の濃度は硫酸濃度80~98質量%、好ましくは82~96質量%、より好ましくは84~94質量%である。

【0056】加水分解および脱炭酸反応の温度（常圧）は、通常、50~180℃であり、好ましくは60~160℃、より好ましくは70~140℃である。

【0057】前段反応は、4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルの転化率が40モル%以上、好ましくは60モル%以上、より好ましくは80モル%以上となるまで行い、同時に反応液中の2, 3, 5, 6-テトラフルオロアニリンの生成量が、原料4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリル基準で、80モル%以下、好ましくは70モル%以下、より好ましくは60モル%以下の場合に前段段階を終了させる。

【0058】次いで、後段階として、前段反応終了後の反応混合物に水を添加して、反応当初に仕込んだ硫酸水溶液の濃度を、50~95質量%、好ましくは60~90質量%、より好ましくは65~85質量%に希釈し、これを後段階の反応条件として反応を続行させる。

【0059】なお、他の方法として、前段反応を比較的低い温度、より具体的には温度50~170℃、好ましくは60~150℃、より好ましくは70~130℃で前段段階の反応を行い、後段反応では、前段反応におけるよりも高い温度、例えば温度60~180℃、好ましくは70~160℃、より好ましくは80~140℃で後段階の反応を行う。

【0060】または、前段反応では、酸性物質濃度、具体的には硫酸濃度を80~98質量%、好ましくは82~96質量%、より好ましくは84~94質量%、かつ反応温度50~170℃、好ましくは60~150℃、より好ましくは70~130℃で反応を行い、次いで後

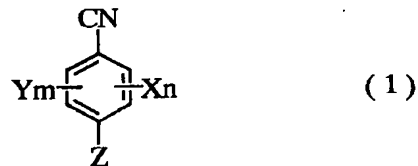
段階として反応器に当初仕込んだ酸性物質の濃度、より具体的には硫酸濃度を、50~95質量%、好ましくは60~90質量%、特に好ましくは65~85質量%に希釈して酸性物質濃度、具体的には硫酸濃度を5~50質量%、より好ましくは10~30質量%低下させ、かつ反応温度を55~180℃、好ましくは70~160℃、特に好ましくは80~140℃の条件で反応、すなわち、反応温度を5~50℃、より好ましくは10~40℃上昇させて反応を行う。前段段階終了の基準は、4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルの転化率が40モル%以上、かつ2, 3, 5, 6-テトラフルオロアニリンの生成量が80モル%以下である。このようにして得られた2, 3, 5, 6-テトラフルオロアニリンは、常法に従って回収して製品とすることができる。

【0061】本発明における第二の発明は、一般式

(1) で表される芳香族シアノ化合物を水性媒体の存在下に加水分解および脱炭酸させて一般式(2)で表される芳香族化合物を生成させた後、得られた該芳香族化合物を水との共沸蒸留によって反応液から回収することを特徴とする、芳香族化合物の製造方法である。

【0062】

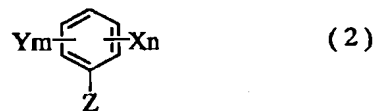
【化20】



【0063】（式中、Xはハロゲン原子であり、Yはシアノ基、ニトロ基またはカルボキシル基であり、Zは-N(R¹)(R²)（ここで、R¹およびR²は、窒素原子上の置換基であって、同一でも異なってもよく、水素原子、または炭素数1~4の直鎖または分岐したアルキル基である。）で表される窒素含有基であり、mは0、1または2であり、nは1、2、3または4であり、但し1≤m+n≤4である。）

【0064】

【化21】



【0065】（式中の記号は一般式(1)と同じ。）

上記化合物は、本願第一の発明と同じである。

【0066】該第二の発明は、該芳香族シアノ化合物を水性媒体の存在下に加水分解および脱炭酸させることを特徴とし、該水性媒体が酸性物質、たとえば硫酸水溶液の濃度が80質量%の条件下で反応させると、第一の発明で説明したように、上記工程(4)や工程(8)の反

アニリンとに分液し、留出した水を反応液に循環する。

【0081】共沸蒸留は、留出物の温度（いわゆる、共沸温度）として、反応容器内で温度80～150℃、好ましくは90～130℃で行う。常圧、減圧のいずれでもよいが常圧のが好ましい。

【0082】なお、このような共沸蒸留は、本願第一の発明の後段階以降で得た反応液においても、同様に応用することができる。

【0083】次に、該水性媒体がアルカリ性物質を含む場合として、一般式（1）で表される芳香族シアノ化合物として4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルを用いて、一般式（2）で表される芳香族化合物として2, 3, 5, 6-テトラフルオロアニリンを製造する場合を本発明の一例として説明する。

【0084】本発明は、4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルを水性媒体として、アルカリ性物質を含む条件下に加水分解して4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸および／またはその塩（例えば、アルカリ性物質が水酸化ナトリウムの場合には、ナトリウム塩）（以下、4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸（塩）と表示する。）を得る工程と、該化合物を脱炭酸反応させる脱炭酸工程と、最後に、得られた2, 3, 5, 6-テトラフルオロアニリンを水との共沸蒸留により回収する工程とからなる。

【0085】上記加水分解工程で使用するアルカリ性物質としては、4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルを加水分解して4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸（塩）を生成し得るものであれば特に制限はなく、例えば、アルカリ金属塩、アルカリ土類金属塩、アミン類などを使用することができる。より具体的には、アルカリ金属塩として、水酸化ナトリウム、水酸化カリウム、炭酸ナトリウム、炭酸カリウム、炭酸水素ナトリウム、炭酸水素カリウムなどが挙げられ、アルカリ土類金属塩として、水酸化カルシウム、炭酸カルシウムなどが挙げられる。なかでも、水酸化ナトリウムを使用することが経済的な理由から好ましい。あるいは水酸化ナトリウムと水酸化カルシウムを併用することが腐食防止の観点から好ましい。また、アミン類としては、ジメチルアミン、トリメチルアミン、エチルアミン、ジエチルアミン、トリエチルアミン、ブチルアミン、ジブチルアミン、トリブチルアミンなどのアルキルアミン類、ピリジン、キノリンなどが挙げられる。これらのアルカリ性物質は単独で使用してもよいし、いずれか2種以上を併用してもよい。

【0086】アルカリ性物質の使用量は、原料4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルの0.1～20質量倍、好ましくは0.3～10質量倍、更に好ましくは0.5～5質量倍である。アルカリ性物質の使用量が多すぎると原料のハロゲン置換反応が起こ

って選択率が低下し、また使用量が少なすぎると反応が円滑に進まなくなる。

【0087】加水分解反応は水性媒体中で行うことが好ましく、水性媒体としては、水を単独で使用しても、あるいは水と混和性の溶媒を併用してもよい。このような溶媒としては、アルコール類、非プロトン性極性溶媒、ケトン類、エステル類などを使用することができる。アルコール類としては、メタノール、エタノール、n-プロパノール、イソプロパノール、エチレングリコール、プロピレングリコールなど、ケトン類としては、アセトン、メチルエチルケトン、メチルイソブチルケトンなど、エステル類としては、酢酸エチル、酢酸プロピル、酢酸ブチルなどの酢酸エステル類などを挙げることができる。非プロトン性極性溶媒としては、ジメチルホルムアミド（DMF）、ジメチルスルホキシド（DMSO）、n-メチルピロリドンなどを挙げることができる。

【0088】水性媒体の使用量は、原料4-アミノ-2, 3, 5, 6-テトラフルオロベンゾニトリルの1～50質量倍、好ましくは2～30質量倍、更に好ましくは3～10質量倍である。使用量が多すぎると目的物の生産性が悪くなり、また使用量が少なすぎると反応が円滑に進まなくなる。

【0089】反応温度は、20～200℃、好ましくは30～150℃、更に好ましくは40～100℃である。反応温度が高すぎると原料のハロゲン置換反応などによる副生成物が増加し、目的物の選択率が低下し、また反応温度が低すぎると工業的に十分な速度で反応が進まなくなり問題である。

【0090】本工程では、アルカリ性物質を使用するので、酸性物質を使用する従来技術に比べて反応器の腐食が著しく軽減される。

【0091】次に脱炭酸工程について説明する。これは、加水分解反応で生成した4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸（塩）の脱炭酸反応を行う工程である。

【0092】脱炭酸反応は、加水分解反応で生成した4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸（塩）を含有する水性媒体をそのまま加熱して脱炭酸させてもよいし、あるいは加水分解工程で使用したアルカリ性物質とは異なるアルカリ性物質を添加して反応させてもよい。このようなアルカリ性物質としては、前記アルカリ性物質が挙げられるが、反応がより円滑に進行し、かつ脱炭酸工程における副反応によって生成するフッ素イオンによる反応器の腐食を防止することができるという理由から、アルカリ土類金属塩が好ましい。このようなアルカリ土類金属塩の使用量は、4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸（塩）に対して、0.01～2質量倍、好ましくは0.02～1質量倍、更に好ましくは0.03～0.5質量倍である。使

ーテトラフルオロベンゾニトリルの合成>攪拌機、温度計および冷却管を備えた500mlの4つ口フラスコにペンタフルオロベンゾニトリル75g(389ミリモル)、酢酸n-プロピル225ml、25%アンモニア水79.5g(アンモニアとして1.165モル)およびテトラブチルアンモニウムブロマイド0.375gを仕込み、25℃で1時間反応させた後、さらに50℃で5時間反応させた。反応終了後、反応液をガスクロマトグラフィー分析したところ、ペンタフルオロベンゾニトリルの転化率は100%であり、目的物である4-アミノ-2,3,5,6-テトラフルオロベンゾニトリルの収率は94%であった。

【0107】4-アミノ-2,3,5,6-テトラフルオロベンゾニトリルを含有する酢酸n-プロピル層を分離し、この層に含有されるフッ化アンモニウムを除去するために、10質量%硫酸ナトリウム水溶液100gで2回洗浄した。その後、酢酸n-プロピル層を加熱して酢酸n-プロピルを留去し、4-アミノ-2,3,5,6-テトラフルオロベンゾニトリル(純度94%)7

4-アミノ-2,3,5,6-テトラフルオロベンゾニトリル
4-アミノ-2,3,5,6-テトラフルオロ安息香酸
2,3,5,6-テトラフルオロアニリン

【0110】(後段反応)上記反応液に水22gを添加して、硫酸水溶液の濃度を80質量%とし、反応を15時間継続した。後段反応における反応器中の硫酸濃度は、80質量%であった。反応終了後、反応液をサンプリングし、液体クロマトグラフィー分析したところ、2,3,5,6-テトラフルオロアニリン収率は98モル%であった。

【0111】(共沸工程)攪拌機、温度計、滴下ロートおよび水分離管を備えた500mlのガラス製4つ口フラスコに水300mlを仕込み、攪拌しながら100℃に昇温し、還流状態を保持した。

【0112】加水分解・脱炭酸工程で得られた反応液を滴下ロートに仕込み、この反応液を電気ヒータによって110℃に保持しながら、上記フラスコ内に1時間かけて滴下し、共沸蒸留により2,3,5,6-テトラフルオロアニリンを水分離管に留出させた。

【0113】水分離管にたまった留出物の上層は水、下層は2,3,5,6-テトラフルオロアニリンであった。留出した水はフラスコ内に循環しながら、2,3,5,6-テトラフルオロアニリンの留出を3時間継続した。

【0114】水分離管からは2,3,5,6-テトラフルオロアニリン39.4gが得られ、ガスクロマトグラフィー分析したところ、純度は99.5%であった。

【0115】加水分解・脱炭酸工程および共沸蒸留工程を合わせたトータルの収率は96.0%であった。加水分解・脱炭酸および共沸蒸留に使用した反応器内壁を目視により観察したところ、いずれの反応器にも腐食は認

3.5gを得た(収率93.6%)。不純物として、2-アミノ-3,4,5,6-テトラフルオロベンゾニトリルが4.5g(6%)含まれていた。

【0108】実施例1

(前段反応)攪拌機、温度計および冷却管を備えた200mlのガラス製4つ口フラスコに、90質量%硫酸水溶液120gを仕込み、攪拌しながら、内温を110℃にした。次に、参考例1で得られた固形物(4-アミノ-2,3,5,6-テトラフルオロベンゾニトリル含有率94%)50gを、110℃に保持した90質量%硫酸水溶液に、攪拌下、4g/hの供給速度で供給した。前段反応における反応器中の硫酸濃度は、90~94質量%であった。供給終了後、更に2時間反応を行った。反応液をサンプリングし、液体クロマトグラフィー分析したところ、4-アミノ-2,3,5,6-テトラフルオロベンゾニトリルの転化率は100モル%であり、生成物は次のとおりであった。

【0109】

65モル%、
10モル%、
20モル%。

められなかった。

【0116】(年間腐食率の測定)上記反応において、年間腐食率を測定した。前記加水分解・脱炭酸工程において、ガラス製フラスコの代わりに内面をフッ素樹脂コーティングした容量500mlのステンレス鋼製セパブルフラスコを用い、ガラステストピース(日本ガイシ(株)製、GL-400、杵型)を界面付近に浸漬し、また硫酸水溶液および固形物の使用量、ならびに固形物の添加速度をそれぞれ3倍にした以外は、前記と同じ加水分解および脱炭酸反応を行った。この反応を2回繰り返し、3回の反応を経たテストピースを取り出し、下記式にしたがって年間腐食率を求めたところ、0.02mm/年であった。

【0117】

【数1】

$$\text{年間腐食率(mm/年)} = \frac{W_0 - W_1}{S} \times \frac{24(\text{hr/日}) \times 365(\text{日/年})}{T}$$

【0118】 W_0 : テストピースのテスト前の質量 (mg)

W_1 : テストピースのテスト後の質量 (mg)

D : テストピースの比重 (mg/mm³)

S : テストピースの表面積 (mm²)

T : テスト時間 (hr)

実施例2

(加水分解および脱炭酸反応)攪拌機、温度計および冷却管を備えた200mlのガラス製4つ口フラスコに、90%硫酸水溶液100gを仕込み、攪拌しながら、内

持した後、上記工程で得られた反応液を、加熱により温度保持が可能な滴下ロートに移し替え、120g/hの滴下速度で滴下した。水分離管に目的物の2, 3, 5, 6-テトラフルオロアニリンが留出するように、反応容器の加熱温度を上昇させながら、反応初期100℃、反応終了時140℃で2, 3, 5, 6-テトラフルオロアニリンを留出させた。留出した2, 3, 5, 6-テトラフルオロアニリンは、受器に抜き出し、一方留出した水は4つ口フラスコに戻しながら、2, 3, 5, 6-テトラフルオロアニリンの留出を3時間継続した。この結果、純度98.5%の2, 3, 5, 6-テトラフルオロアニリン32gが得られた。収率は98.5%であった。

【0131】加水分解・脱炭酸および共沸蒸留に使用した反応器内壁を目視により観察したところ、いずれの反応器にも腐食は認められなかった。さらに、加水分解・脱炭酸に使用した反応器の年間腐食率を算出したところ0.09mm/年であった。

【0132】比較例1

4-アミノ-2, 3, 5, 6-テトラフルオロベンズニトリルから2, 3, 5, 6-テトラフルオロアニリンを製造した。すなわち、攪拌機、温度計、滴下ロートおよび水分離管を備えた200mlの4つ口フラスコに60%硫酸100gを仕込み、140℃に昇温した後、原料である4-アミノ-2, 3, 5, 6-テトラフルオロベンズニトリル（純度94%、不純物として2-アミノ-3, 4, 5, 6-テトラフルオロベンズニトリルを6%含有）36gを滴下速度6g/hで添加した。反応によって生成する2, 3, 5, 6-テトラフルオロアニリンは水と共沸させながら、水分離管に導き、2, 3, 5, 6-テトラフルオロアニリンと水とに分離させた。留出する水と同量の水を反応器に供給しながら6時間反応を継続した。反応終了後、ガスクロ分析による原料転化率は96モル%であり、留出した2, 3, 5, 6-テトラフルオロアニリンを分析したところ、純度95.3%、収率82.5%であった。

【0133】なお、反応器を目視により観察したところ、反応器内壁にフッ化水素によるとみられる腐食が認められた。また、年間腐食率は、0.3mm/年であった。

【0134】実施例10

（加水分解工程）参考例1で得られた固形物14.7g（4-アミノ-2, 3, 5, 6-テトラフルオロベンズニトリル含有量94%）を攪拌機、温度計および冷却管を備えて100mlの4つ口フラスコに仕込み、さらに10%水酸化ナトリウム水溶液80gを添加した後、50℃で8時間反応させた。反応終了後、反応液をガスク

ロマトグラフィー分析したところ、4-アミノ-2, 3, 5, 6-テトラフルオロベンズニトリルの転化率は100%であり、目的物である4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸の収率は98%であった。

【0135】（脱炭酸工程）加水分解工程で得られた反応液に濃硫酸9.8g（加水分解工程で使用した水酸化ナトリウムと当量）を添加し、100mlのオートクレープに仕込んだ。内温を130℃に昇温し、反応器の内部圧力を0.2MPaに保持しながら8時間反応を行った。反応終了後、反応液を液体クロマトグラフィー分析したところ、4-アミノ-2, 3, 5, 6-テトラフルオロ安息香酸の転化率は100%であり、2, 3, 5, 6-テトラフルオロアニリンの収率は95%であった。

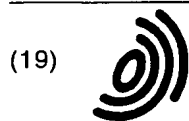
【0136】（共沸工程）攪拌機、温度計、滴下ロートおよび水分離管を備えた200mlの4つ口フラスコに、脱炭酸工程で得られた反応液を仕込み、100℃に昇温して、その温度に保持した。滴下ロートに仕込んだ水を滴下しながら、水分離管に目的物の2, 3, 5, 6-テトラフルオロアニリンが留出するように、加熱温度を上昇させながら、反応容器内の留出初期温度100℃、留出終了時140℃で2, 3, 5, 6-テトラフルオロアニリンを留出させた。

【0137】留出した2, 3, 5, 6-テトラフルオロアニリンは、受器に抜き出し、一方留出した水は4つ口フラスコに戻しながら、2, 3, 5, 6-テトラフルオロアニリンの留出を3時間継続した。この結果、純度98.5%の2, 3, 5, 6-テトラフルオロアニリン11.3gが得られた。

【0138】加水分解工程、脱炭酸工程および共沸工程を合わせたトータルの収率は94.5%であった。加水分解、脱炭酸および共沸に使用した反応器内部を目視により観察したところ、いずれの反応器にも腐食は認められなかった。また、加水分解工程及び脱炭酸工程に使用した反応器の年間腐食率は、0.02mm/年であった。

【0139】

【発明の効果】本発明の方法によれば、4-アミノ-2, 3, 5, 6-テトラハロゲノベンズニトリルなどのハロゲン含有芳香族化合物を原料として、2, 3, 5, 6-テトラハロゲノアニリンなどの対応する芳香族化合物を高収率で製造することができる。特に、ガラス製あるいはガラスライニング製反応器中で低純度の4-アミノ-2, 3, 5, 6-テトラハロゲノベンズニトリルの加水分解や脱炭酸および共沸蒸留を行っても、反応器の腐食を引き起こすことなく、高収率で製造することができる。



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(54) **Method for production of aromatic compounds**

(57) For the production of an aromatic compound by hydrolyzing and decarboxylating a corresponding aromatic cyano compound in the presence of an acidic substance, this invention provides a method for the production of the aromatic compound, characterized by carrying out the reactions of hydrolysis and decarboxylation in

multiple steps. Particularly when the aromatic cyano compound contains a halogen, this method effectively prevents the reaction vessels from being corroded by the by-produced hydrogen halogenide and enables the target compound to be produced in a high yield.

Description

[0001] The invention relates to a method for the production of aromatic compounds, and more particularly to a method for the production of aromatic compounds by using a halogen-containing aromatic cyano compound as a raw material, performing hydrolysis and decarboxylation on the raw material without inducing corrosion of the reaction vessel to obtain a corresponding aromatic compound aimed at with a high yield.

[0002] The tetrahalogenoanilines include important compounds, which are used as intermediate raw materials for pharmaceutical preparations and agricultural pesticides. Methods for producing 2,3,5,6-tetrafluoroaniline are described in the official gazettes of JP A 06 244,756 and JP A 08 268,979, for example. The method described in the official gazette of JP A 06 244,756 is claimed to obtain 2,3,5,6-tetrafluoroaniline by using a pentafluorobenzoic acid as a raw material and causing it to react with ammonia in an aqueous medium and consequently undergo amination and decarboxylation. It is described that the pentafluorobenzoic acid as the raw material can be obtained by hydrolyzing pentafluorobenzonitrile in an aqueous sulfuric acid solution and that though the aqueous reaction solution contains excess sulfuric acid and ammonium sulfate as a reaction product besides the pentafluorobenzoic acid, the obtained pentafluorobenzoic acid can be used directly in its unmodified form without being washed with water in the reaction for the production of 2,3,5,6-tetrafluoroaniline.

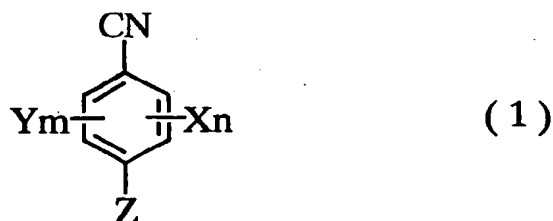
[0003] Then, the method disclosed in the official gazette of JP A 08 268,979 is claimed to obtain 2,3,5,6-tetrafluoroaniline by using 4-amino-2,3,5,6-tetrafluorobenzonitrile as a raw material, adding it together with water to an aqueous sulfuric acid solution thereby enabling the 2,3,5,6-tetrafluoroaniline formed consequently by hydrolysis and decarboxylation to be distilled with water by azeotropic distillation and meanwhile causing the reaction of hydrolysis and decarboxylation to proceed. Since the hydrofluoric acid which is formed by a secondary reaction corrodes reaction devices made of stainless steel or lined with glass, this method immediately distills the formed 2,3,5,6-tetrafluoroaniline azeotropically with water and feeds water to the reaction vessel for the purpose of keeping the concentration of sulfuric acid therein at a fixed level, with the result that the reaction vessel is prevented from corrosion and the 2,3,5,6-tetrafluoroaniline is obtained in a high yield.

[0004] Generally, when a given reaction involves use of sulfuric acid, for example, the reaction vessel for this reaction is made of glass or lined with glass because the vessel would be destined to incur corrosion if it was made of iron or steel. The method disclosed in the aforementioned official gazette of JP A 08 268,979 is directed at preventing a reaction vessel from corrosion, when the method uses 4-amino-2,3,5,6-tetrafluorobenzonitrile in a low purity as a raw material, however, the vessel undergoes discernible corrosion. When the raw material is subjected to a treatment for removal of impurities in advance, the treatment would be capable of preventing the vessel from corrosion but suffer disadvantage in adding to the number of steps for the process.

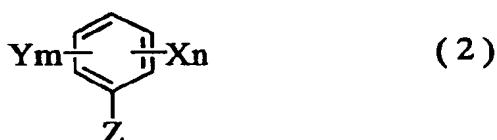
[0005] In a working example cited in the official gazette of JP A 08 268,979, the 2,3,5,6-tetrafluoroaniline is reported to be obtained in a yield of 82.5%. Thus, the desirability of further enhancing the yield finds readily approval.

[0006] The present inventor, as a result of a detailed study on a path of synthesis of an aromatic amino compound obtained by the hydrolysis and decarboxylation of a halogen-containing aromatic cyano compounds and on a secondary product formed in the synthesis, has found that the occurrence of impurities can be repressed, the yield of the product can be enhanced, and the corrosion of a reaction vessel can be prevented by carrying out the reaction of hydrolysis and decarboxylation as divided into two discrete steps in using different conditions. As a result of further continuing a detailed study on the timing for effecting the distillation of the target product from the reaction system, he has discovered that the corrosion of the reaction vessel can be prevented and the target aromatic amino compound can be obtained in a high yield by performing the hydrolysis and decarboxylation in the presence of an aqueous medium thereby effecting formation of the aromatic amino compound and thereafter expelling the aromatic amino compound through azeotropic distillation with water. The present invention has been perfected based on the knowledge thus acquired. Specifically, this invention is aimed at providing the methods stated in the following items (1) to (3).

(1) In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the reactions of hydrolysis and decarboxylation in multiple steps.

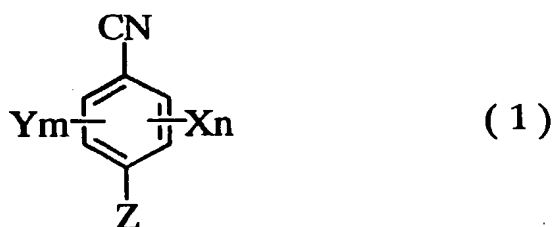


10 (wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by -N(R¹) (R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 ≤ m + n ≤ 4.)

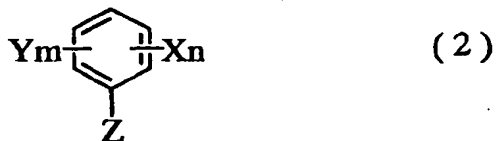


(wherein the symbols have the same meanings as in the general formula (1).)

25 (2) A method for the production of an aromatic compound, characterized by forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently recovering the obtained aromatic compound from the reaction solution by azeotropic distillation with water.

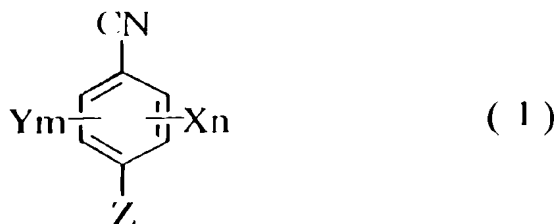


40 (wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by -N(R¹) (R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 ≤ m + n ≤ 4.)



(wherein the symbols have the same meanings as in the general formula (1).)

55 (3) In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the hydrolysis and decarboxylation in multiple steps and effecting the recovery of the formed aromatic compound from the reaction solution by azeotropic distillation with water.



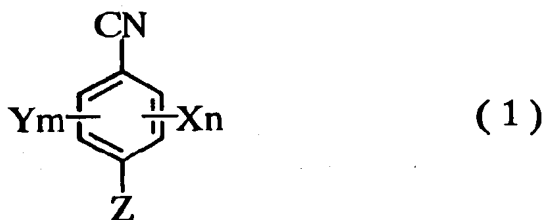
(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{N(R}^1\text{)}(\text{R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m + n \leq 4$)



(wherein the symbols have the same meanings as in the general formula (1))

[0007] According to the method of this invention, by using a raw material such a halogen containing aromatic compound as 4-amino-2,3,5,6-tetrahalogenobenzonitrile, it is made possible to produce such a corresponding aromatic compound as 2,3,5,6-tetrahalogenoaniline in a high yield. Even when the 4-amino-2,3,5,6-tetrahalogenobenzonitrile formed in low purity is hydrolyzed, decarboxylated, and azeotropically distilled particularly in the reaction vessel made of glass or lined with glass, the production of the aromatic compound can be attained in a high yield without inducing corrosion of the reaction vessel.

[0008] The first aspect of this invention is in the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the reactions of hydrolysis and decarboxylation in multiple steps.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{N(R}^1\text{)}(\text{R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m + n \leq 4$.)

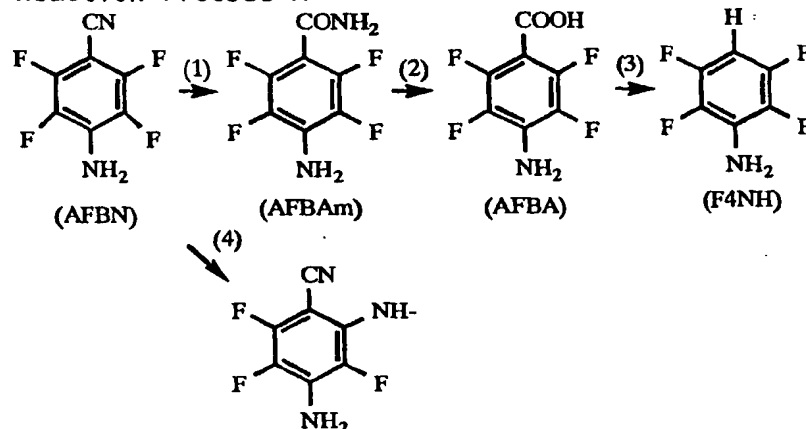


(wherein the symbols have the same meanings as in the general formula (1).)

[0009] When 4-amino-2,3,5,6-tetrafluorobenzonitrile of low purity is used as a raw material containing an aromatic cyano compound represented by the general formula (1), for example, the possibility of the reaction vessel being corroded with hydrogen fluoride will arise. By a study of the cause for this trouble, it has been found that the impurities contained in the raw material such as, for example, 2-amino-3,4,5,6-tetrafluorobenzonitrile is liable to cause such an origin of the trouble. From a further study on the relation of the trouble with corrosion, the inventor has acquired the following knowledge.

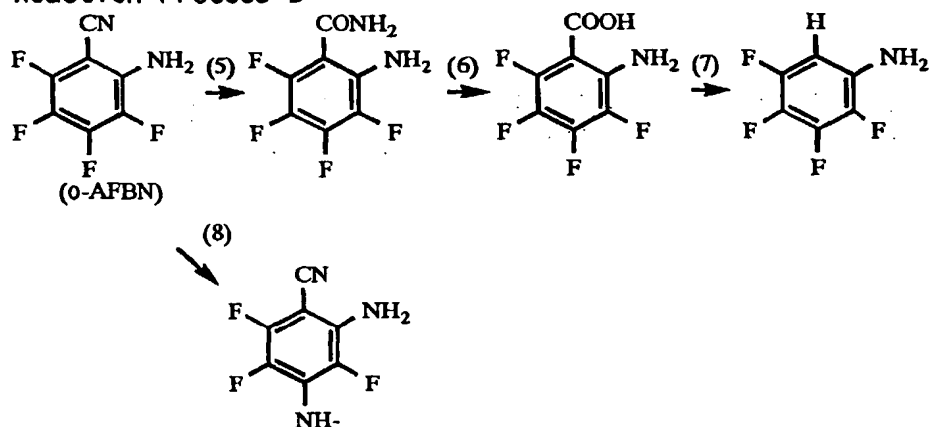
[0010] First, when 2,3,5,6-tetrafluoroaniline (F4NH) is produced by hydrolyzing and decarboxylating 4-amino-2,3,5,6-tetrafluorobenzonitrile (NFBN) with sulfuric acid, the reaction of hydrolysis and the reaction of decarboxylation are thought to proceed through a reaction process A which is composed of such steps (1) to (3) as shown below.

Reaction Process A



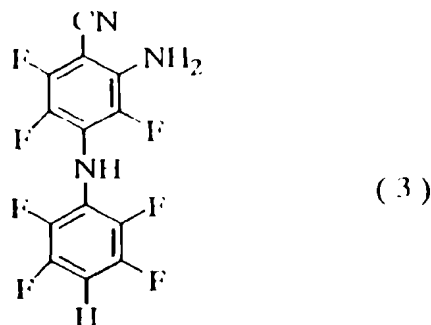
[0011] If the raw material compound to be used has low purity, however, the reaction process mentioned above is liable to by-produce hydrogen fluoride and induce the reaction vessel made of glass or lined with glass to succumb to corrosion. The inventor's attention has been turned particularly to 2-amino-3,4,5,6-tetrafluorobenzonitrile (o-AFBN) among other impurities contained in the raw material compound. Where the impurity compound is contained in the raw material, the process of the reactions of hydrolysis and decarboxylation permits the occurrence of the reaction process B which is formed of the following steps (5) to (7) or the occurrence of the reaction through the step (8).

Reaction Process B

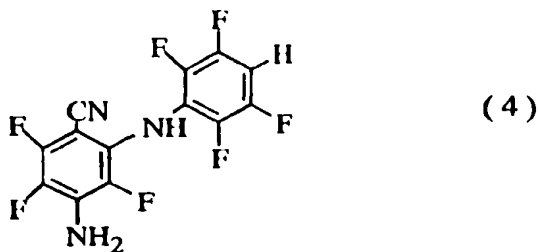


[0012] When the step (8) is passed, the substitution reaction occurring between the amino group of the target compound, 2,3,5,6-tetrafluoroaniline (F4NH), and the fluorine atom at the 4 position of 2-amino-3,4,5,6-tetrafluorobenzonitrile (o-AFBN) forms a compound represented by the following formula (3) and, at the same time, by-produces hydrogen

fluoride.



When the raw material 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) passes the step (4) as a secondary reaction in the reaction process A, the relevant reaction forms a compound represented by the following formula (4) mentioned below and, at the same time, by produces hydrogen fluoride. For, the step (4) causes the fluorine atom located at the ortho position of the cyano group of the raw material AFBN to react with the F4NH compound obtained at the step (3) to produce a compound represented by the following formula (4) and, at the same time, by produce hydrogen fluoride. The speed of this secondary reaction is estimated to be greater in the step (8) than in the step (4). To be specific, the corrosion of the reaction vessel with the by-produced hydrogen fluoride gains in prominence as the impurities in the raw material grow in concentration.



[0013] Besides the elucidation described above, it has been found that when the process of hydrolysis and decarboxylation is performed in one step in the presence of an acidic substance under the condition using an aqueous sulfuric acid solution of a concentration of 80 weight %, for example, the reactions of the step (1) and the step (5) proceed much faster than the reactions of the step (4) and the step (8) and that the reactivity with fluorine atoms is degraded because the amino group forms a sulfate under the condition. As a result, the secondary production of hydrogen fluoride is repressed and the corrosion of the reaction vessel is effectively prevented.

[0014] To continue the explanation, the compound to be formed through the steps (4) and (8) in the reaction processes A and B mentioned above possibly assumes a structure other than the structures of the compounds represented by the formulas (3) and (4) mentioned above, depending on the form of the substitution reaction.

[0015] The structures depicted at the leading ends of the paths (4) and (8) of the reaction processes A and B mentioned above are partial structures of the compounds represented by the formulas (3) and (4) mentioned above.

[0016] It has been further found that the secondary production of hydrogen fluoride is repressed to a greater extent by performing the aforementioned reactions of hydrolysis and decarboxylation as divided in at least two steps using different conditions instead of completing them in one step. Specifically, in the multiple stages which are divided into a former step and a latter step, it is made possible to attain more effective prevention of the reaction vessel from corrosion by causing the reaction of 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) to proceed till the conversion ratio exceeds about 40 mol% and performing this reaction under such conditions that the product thereof has 4-amino-2,3,5,6-tetrafluorobenzamide (AFBAm) as a main component thereof and consequently enabling the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) to exceed 40 mol%, preferably 60 mol%, and more preferably 80 mol% while repressing the formation of 2,3,5,6-tetrafluoroaniline (F4NH) in the former step (former step reactions) and completing the hydrolysis and the decarboxylation in the latter step or thereafter.

[0017] This more effective prevention of the corrosion may be logically explained by a postulate that though the conversion ratio of 2-amino-3,4,5,6-tetrafluorobenzonitrile (o-AFBN) reaches nearly the same level, the chance of con-

tact of o-AFBN with the target product, 2,3,5,6-tetrafluoroaniline (F4NH), is allayed or the chance of contact of the o-AFBN with the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) is allayed, with the result that the formation of the compound represented by the formula (3) or the formula (4) mentioned above is repressed, and at the same time that the formation of hydrogen fluoride is repressed. Incidentally, the compound represented by the formula (3) or the formula (4) mentioned above is merely intended as an example for illustrating the relation between the presence of impurities and the occurrence of corrosion. This invention is not limited to the presence of this compound and to the repression of the formation thereof. This invention will be described in detail below.

[0018] The aromatic cyano compound represented by the general formula (1) which is used in this invention is such that in the general formula (1), the symbol Z denotes a nitrogen-containing group represented by the formula -N(R¹)(R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms). As concrete examples of the nitrogen-containing group, amino group, monomethyl amino group, dimethyl amino group, monoethyl amino group, diethyl amino group, monopropyl amino group, and dipropyl amino group may be cited. Among them, the amino group proves particularly suitable. The symbol Y denotes a cyano group, nitro group, or carboxyl group, the cyano group being preferable. The halogen atom denoted by the symbol X is a fluorine atom, chlorine atom, or bromine atom, the fluorine atom being preferable. In the occurrence of a plurality of X's, the atoms denoted thereby may be identical or not identical with one another.

[0019] As concrete examples of the aromatic cyano compound represented by the general formula (1), 4-amino-2,3,5,6-tetrahalogenobenzonitrile, 4-monomethylamino-2,3,5,6-tetrahalogenobenzonitrile, 4-dimethylamino-2,3,5,6-tetrahalogenobenzonitrile, 4-amino-3,5,6-trihalogenophthalonitrile, 4-monomethylamino-3,5,6-trihalogenophthalonitrile, and 4-dimethylamino-3,5,6-trihalogenophthalonitrile may be cited. Among them, 4-amino-2,3,5,6-tetrahalogenobenzonitrile is used particularly advantageously. The halogen atoms considered herein may be individually identical or not identical with one another and may be each a fluorine atom, chlorine atom, or bromine atom. In all the possible species of 4-amino-2,3,5,6-tetrahalogenobenzonitrile, 4-amino-2,3,5,6-tetrafluorobenzonitrile having fluorine atoms as the halogen atoms is used particularly advantageously.

[0020] When the aromatic cyano compound mentioned above is hydrolyzed and decarboxylated in this invention, the reaction thereof is carried out in the presence of an acidic substance to produce the aromatic compound represented by the general formula (2).

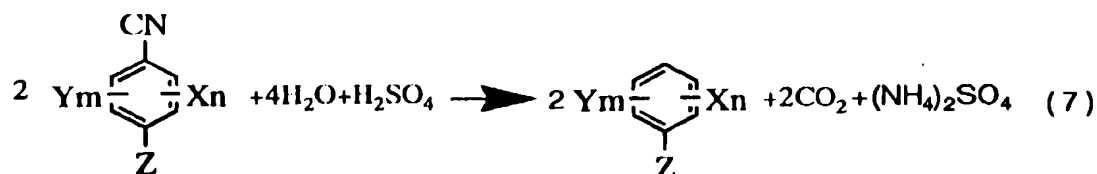
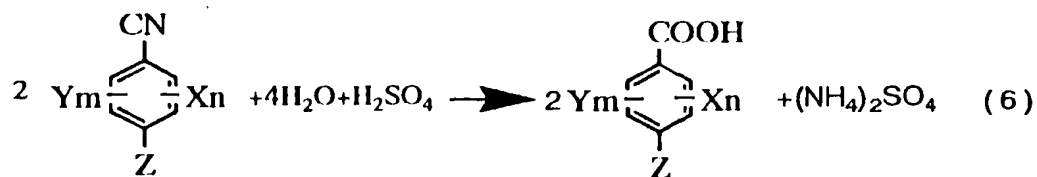
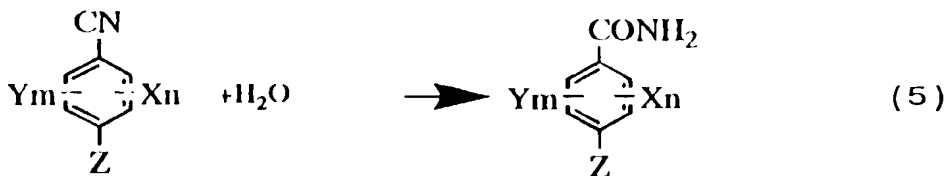
[0021] The acidic substance to be used in this reaction does not need to be particularly discriminated, but is only required to be capable of hydrolyzing and decarboxylating the aromatic cyano compound represented by the general formula (1) and consequently forming the aromatic compound represented by the general formula (2). As typical examples of the acidic substance, inorganic acids such as sulfuric acid, hydrochloric acid, and nitric acid and organic acids such as acetic acid, propionic acid, and butyric acid may be cited. Among them, sulfuric acid is used particularly advantageously. The reason for this preference of sulfuric acid is that the reactivity with fluorine atoms is lowered and the reactions of the step (1) and the step (5) are enabled to proceed faster than the reactions of the step (4) and the step (8) because the amino group of the aromatic cyano compound forms a sulfate.

[0022] As the reaction vessel in the method of production according to this invention, the reaction vessel which is made of iron or stainless steel and is popularly adopted may be used. When this reaction vessel is liable to be corroded by the acidic substance or by a secondary product which occurs in the process of the reaction as when sulfuric acid is used, for example, the use of a reaction vessel made of glass or lined with glass is commendable. Otherwise, a reaction vessel which is coated with such a corrosion-resistant material as fluorocarbon resin may be used. In consideration of such factors as cost, it is common to use a reaction vessel which is made of glass or lined with glass.

[0023] The acidic substance is used together with water of an amount enough for the advance of the reactions of hydrolysis and decarboxylation of the raw material aromatic cyano compound. The acidic substance so used is preferred to have a high concentration. The reason for the high concentration of the acidic substance is that even when the raw material to be used has low purity and contains impurities, the target product, 2,3,5,6-tetrahalogenoaniline, can be obtained in a high yield without inducing corrosion of the reaction vessel. The high yield of this product may be logically explained by a supposition that when the reactions of hydrolysis and decarboxylation are carried out by using an aqueous sulfuric acid solution of a comparatively high concentration, for example, the cyano group of the impurity, 2-amino-3,4,5,6-tetrahalogenobenzonitrile, is hydrolyzed fast, the electron attracting property of the cyano group is degraded, and the readily displaceable fluorine atom at the para position relative to the cyano group is rendered less susceptible of the reaction of substitution. Further, it is inferred that since the amino group which incites fluorine atoms to undergo a reaction of nucleophilic substitution forms a salt with sulfuric acid, the reactivity of nucleophilic substitution manifested on the fluorine atoms is degraded. Though this invention is not restrained by the foregoing theoretical consideration, the acidic substance is preferred to be used in the form of an aqueous solution. The concentration of the acidic substance in this aqueous solution is properly in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight %. The reason for this range is that the product acquires the characteristic properties mentioned above when the concentration is in this range. Incidentally, the con-

centration of the acidic substance mentioned here means the concentration of the acidic substance which exists during the charging of the reaction vessel with the raw material or during the course of the reaction.

[0024] When an aqueous solution of sulfuric acid is used as the acidic substance, for example, since the reactions represented by the following chemical formulas (5), (6), and (7) proceed as shown by the schema in consequence of the addition of the raw material compound to the reaction mixture, the water and the sulfuric acid forming the aqueous solution are consumed proportionately and the concentration of the acidic substance in the aqueous solution is changed accordingly. Thus, the concentration of sulfuric acid which is found by determining the ratio of formation of the product in the reaction solution as by means of liquid chromatography, for example, and computing the amount of water and the amount of sulfuric acid remaining in the reaction solution based on the following chemical formulas, is the concentration of the acidic substance contemplated by this invention.



[0025] This invention is characterized by performing the reactions of hydrolysis and decarboxylation in multiple stages. In the method of this invention for the production of the aromatic compound, the reaction for hydrolyzing the CN group of the aromatic cyano compound represented by the general formula (1) into the COOH group and the reaction for decarboxylating the COOH group into the hydrogen atom proceed parallelly. The term "reactions of hydrolysis and decarboxylation" as used in this invention, therefore, is meant to express the hydrolysis and the decarboxylation collectively as a series of reactions. The expression that "the hydrolysis and the decarboxylation are performed in multiple steps," therefore, means to divide the aforementioned series of reactions into a former step in which the reactions proceed till a certain state and a latter step in which the target product is obtained at the end of the reactions. Properly, the reaction of hydrolysis is performed to a prescribed extent and thereafter, with the product of the hydrolysis left unseparated, the reaction of decarboxylation is continued under different conditions till the reactions are completed. When the reactions of hydrolysis and decarboxylation are performed in multiple stages as described above, the target product can be obtained in a high yield because the former step which is intended to effect partial hydrolysis serves to lower the reactivity of the substituent located at the para position or the ortho position with the cyano group and repress the formation of a secondary product and, particularly even when the raw material aromatic cyano compound contains impurities having halogen atoms as the component, Z, and prevent the reaction vessel from being corroded owing to the secondary production of hydrogen halogenide, and the latter step serves to complete the reactions.

[0026] The reactions of hydrolysis and decarboxylation in this invention are initiated by adding the raw material aromatic cyano compound to the reaction vessel. The reaction vessel may be charged preparatorily with the aqueous solution of the acidic substance as described above. The raw material may be added to the reaction vessel all at once, sequentially, or continuously. For this invention, the sequential addition of the raw material proves favorable in respect that it enables the selectivity of the reaction to be heightened and prevents the reaction vessel from being corroded. When the raw material is in a solid state, it may be fed to the reaction vessel in its unmodified form, or after being pulverized into a powdery state, or after being heated to a temperature higher than the melting point and consequently reduced to a molten state.

[0027] The temperature of the reactions of hydrolysis and decarboxylation is generally in the range of 50 to 180°C, preferably in the range of 60 to 160°C, and more preferably in the range of 70 to 140°C under normal pressure. The pressure may be normal pressure, reduced pressure, or increased pressure, whichever fits the occasion best. Generally, the reactions are carried out under normal pressure or reduced pressure.

[0028] In this invention, the former step reactions are so performed that the conversion ratio of the raw material aromatic cyano compound reaches a level of not lower than 40 mol %, preferably not lower than 60 mol %, and more preferably not lower than 80 mol % and they are terminated under such conditions that the amount of the final product (the target product, which is the aromatic compound represented by the general formula (2)) to be formed is not more than 80 mol %, preferably not more than 70 mol %, and more preferably not more than 60 mol %, based on the raw material aromatic cyano compound. In other words, the reaction mixture obtained at the end of such former step reactions are enabled to contain an amide compound as the main component. Then, for the latter step reactions, the reaction conditions are so selected that the reaction of carboxylation and decarboxylation of the amide group or the reaction of decarboxylation of the carboxyl group proceeds efficiently until completion.

[0029] The reaction conditions which fulfill the conversion ratio and the amount of formation mentioned above, specifically with respect to the reaction temperature and the concentration of the acidic substance in the aqueous solution may be properly selected from the aforementioned ranges of reaction temperature and concentration of aqueous solution with respect to the contents of the reactions mentioned above. As the conditions of the former step reactions, the concentration of the acidic substance in the aqueous solution, more specifically the concentration of sulfuric acid, to be used is properly in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and particularly in the range of 84 to 94 weight %. As the conditions of the latter step reactions, the concentration of the acidic substance is lowered by adding water to the reaction system to a level in the range of 50 to 95 weight %, preferably in the range of 60 to 90 weight %, and particularly in the range of 65 to 85 weight %. Specifically, the concentration of the acidic substance in the latter step is lowered from the concentration of the acidic substance in the former step by a margin in the range of 5 to 50 weight %, preferably in the range of 10 to 30 weight %. Otherwise, the reaction temperature is elevated from that of the former step by a margin in the range of 5 to 50°C, and preferably in the range of 10 to 40°C. As a result, the formation of the aromatic compound as the final product is repressed and the reaction of the raw material aromatic cyano compound is promoted by the former step reactions and the reaction of carboxylation and decarboxylation or the reaction of decarboxylation is expedited and completed fast by the latter step reactions. In this respect, the method for the production of the aromatic compound is characterized by performing the reactions while varying the conditions of lowering the concentration of the acidic substance and/or raising the reaction temperature in the former step and the latter step in the multiple steps.

[0030] This invention is particularly effective when the raw material to be used contains as an impurity a compound having the nitrogen-containing group present in the aromatic cyano compound located at a different position. To be specific, the possibility of the aforementioned reactions by-producing the hydrogen halogenide is high when 4-amino-2,3,5,6-tetrahalogenobenzonitrile is used as the aromatic cyano compound and it contains as an impurity 2-amino-3,4,5,6-tetrahalogenobenzonitrile (o-AFBN), for example. By this invention, it is made possible to repress the secondary production of the hydrogen halogenide and preclude the occurrence of such problems as corrosion.

[0031] When 4-amino-2,3,5,6-tetrafluorobenzonitrile is used, for example, as the raw material, the conventional method necessitates a process for preparatorily purifying this raw material by such a treatment as recrystallization. By this invention, however, it is made possible to obtain the target product in a high yield without requiring such a process of purification. The 4-amino-2,3,5,6-tetrafluorobenzonitrile can be produced, for example, by causing this compound to form a diphasic state by the use of water and an organic solvent capable of forming a dibasic state with water and allowing the pentafluorobenzonitrile in the dibasic state to react with ammonia. The reaction temperature in this case is generally not higher than 70°C. As typical examples of the organic solvent, aliphatic acid esters, ketones, and benzonitriles may be cited. Thus, this invention enables the target product, i.e. the aromatic compound represented by the general formula (2), efficiently in a high yield even when the 4-amino-2,3,5,6-tetrafluorobenzonitrile containing the impurity formed by such a method is used in its unmodified form. Incidentally, the 4-amino-2,3,5,6-tetrafluorobenzonitrile formed by the method mentioned above may be used after being refined as by recrystallization to a higher degree of purity. In any event, this invention does not need to impose any limitation on the purity of 4-amino-2,3,5,6-tetrafluorobenzonitrile. Generally, so long as the purity is in the range of 80 to 100 weight %, preferably in the range of 90 to 99 weight %, the target product can be obtained efficiently without entailing such problems as the corrosion of the reaction vessel. The method of this invention is effective when the 4-amino-2,3,5,6-tetrafluorobenzonitrile which contains such an impurity as 2-amino-3,4,5,6-tetrafluorobenzonitrile and shows a purity of not higher than 97%, or not higher than 95% is used in the reaction.

[0032] Now, this invention will be described below with reference to the operation of producing 2,3,5,6-tetrafluoroaniline by using 4-amino-2,3,5,6-tetrafluorobenzonitrile as the raw material and sulfuric acid as the acidic substance.

[0033] In this invention, the reactions of hydrolysis and decarboxylation are generally fulfilled by feeding the aqueous solution of sulfuric acid to the reaction vessel made of glass or lined with glass and adding thereto 4-amino-

2,3,5,6-tetrafluorobenzonitrile as the raw material. The raw material may be added to the reaction vessel all at once, or sequentially or continuously. The sequential addition of the raw material, however, proves favorable because it gives high selectivity of the reaction and prevents the reaction vessel from corrosion. When the raw material is added sequentially, the speed of this addition may be properly selected. Favorably, this addition is made at a rate in the range of 0.1 to 20 weight parts, and preferably in the range of 1 to 10 weight parts per hour, based on 100 weight parts of the aqueous solution of sulfuric acid. The addition of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile, is preferred to be completed prior to the termination of the former step reactions.

[0034] The sulfuric acid is used in an amount enough for permitting smooth advance of the reactions of hydrolysis and decarboxylation of 4-amino-2,3,5,6-tetrafluorobenzonitrile together with water. Generally, it is used as an aqueous sulfuric acid solution. The concentration of sulfuric acid in the aqueous sulfuric acid solution is in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight %.

[0035] The temperature of the reactions of hydrolysis and decarboxylation under normal pressure is generally in the range of 50 to 180°C, preferably in the range of 60 to 160°C, and more preferably in the range of 70 to 140°C.

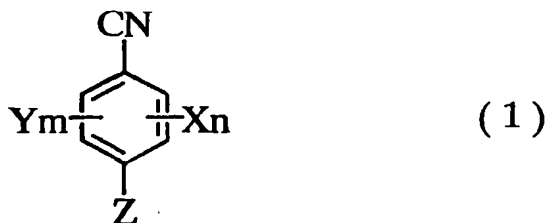
[0036] The former step reactions are performed till the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile reaches a level of not lower than 40 mol %, preferably not lower than 60 mol %, and more preferably not lower than 80 mol % and are terminated when the amount of 2,3,5,6-tetrafluoroaniline formed in the reaction solution is not more than 80 mol %, preferably not more than 70 mol %, and more preferably not more than 60 mol %, based on the amount of 4-amino-2,3,5,6-tetrafluorobenzonitrile as the raw material.

[0037] Subsequently, the latter step of the process comprises adding water to the reaction mixture formed after completion of the former step reactions thereby diluting the initially charged aqueous sulfuric acid solution to a concentration in the range of 50 to 95 weight %, preferably in the range of 60 to 90 weight %, and more preferably in the range of 65 to 85 weight % and continuing the reactions on the resultant diluted reaction mixture.

[0038] Another method of this invention comprises performing the former step reactions at a comparatively low temperature, specifically a temperature in the range of 50 to 170°C, preferably in the range of 60 to 150°C, and more preferably in the range of 70 to 130°C and performing the latter step reactions at a higher temperature than for the former step reactions, specifically at a temperature in the range of 60 to 180°C, preferably in the range of 70 to 160°C, and more preferably in the range of 80 to 140°C.

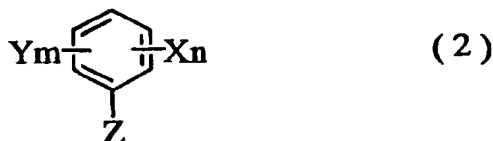
[0039] The former step reactions are performed with the concentration of the acidic acid, specifically the concentration of sulfuric acid, fixed at a level in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight % and the reaction temperature at a level in the range of 50 to 170°C, preferably in the range of 60 to 150°C, and more preferably in the range of 70 to 130°C. Subsequently the latter step reactions are performed with the concentration of the acidic substance, specifically the concentration of sulfuric acid, initially fed to the reaction vessel lowered by dilution to a level in the range of 50 to 95 weight %, preferably 60 to 90 weight % more preferably in the range of 65 to 85 weight % with a margin in the range of 5 to 50 weight %, preferably in the range of 10 to 30 weight % and the reaction temperature increased to a level in the range of 55 to 180°C, preferably in the range of 70 to 160°C and more preferably in the range of 80 to 140°C with a margin in the range of 5 to 50°C, preferably in the range of 10 to 40°C. As the standards for the completion of the former step reactions, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile is not less than 40 mol % and the amount of formation of 2,3,5,6-tetrafluoroaniline is not more than 80 mol %. The 2,3,5,6-tetrafluoroaniline which is consequently obtained can be recovered and turned into a finished product by following the ordinary procedure.

[0040] The second aspect of this invention is the method for the production of an aromatic compound, characterized by forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently recovering the obtained aromatic compound from the reaction solution by azeotropic distillation with water.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by -N(R¹)(R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2,

and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m + n \leq 4$.)



10 (wherein the symbols have the same meanings as in the general formula (1).)

[0041] The compound mentioned above is the same as that of the first aspect of this invention.

[0042] The second invention described above is characterized by hydrolyzing and decarboxylating the aromatic cyano compound in the presence of an aqueous medium. When the reactions are performed by using as the aqueous medium, the aqueous solution of an acidic substance such as, for example, sulfuric acid, and fixing the concentration of the acidic substance at a level of 80 weight %, the reactivity with fluorine atoms is degraded and the secondary production of hydrogen fluoride is repressed because the reactions of the step (1) and the step (5) proceed much faster than the reactions of the step (4) and the step (8) and the amino group forms a sulfate as described already in the first invention. When the aqueous medium is an alkaline substance, the target compound can be produced even with the alkaline substance. Further, by azeotropically distilling the reaction solution, the target compound can be produced in a high yield without inducing corrosion of the reaction vessel. Thus, the second aspect of this invention is enabled to produce the aromatic compound in a high yield by recovering the target compound formed in the presence of the aqueous medium by azeotropic distillation with water from the reaction solution, no matter whether the hydrolysis and the decarboxylation are effected in one step or the reactions of hydrolysis decarboxylation are effected in multiple steps, i.e. in at least not less than two steps using different reaction conditions.

[0043] The aqueous medium for use in this invention is only required to be capable of dissolving the raw material compound and may be an acidic substance or an alkaline substance. It may contain other compounds, alcohols, and aprotic polar solvents, for example.

[0044] As the aqueous medium, the acidic substance used for the first aspect of this invention may be used. As typical examples of the aqueous medium, inorganic acids such as sulfuric acid, hydrochloric acid, and nitric acid and organic acids such as acetic acid, propionic acid, and butyric acid may be cited. Among them, sulfuric acid is used particularly advantageously. First, when the aqueous medium contain an acidic substance, the concentration of the acidic substance in the aqueous medium is in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %. The expression "concentration of the acidic substance contained in the aqueous medium" as used herein means the concentration of the acidic substance existing during the charging of the reaction vessel or during the process of the reaction.

[0045] Now, this invention will be described below with reference to one example thereof, i.e. the procedure wherein the aqueous medium is an acidic substance, sulfuric acid is used as the acidic substance, and 4-amin-2,3,5,6-tetrafluorobenzonitrile is used as the raw material compound.

[0046] This invention can be extensively applied to reaction solutions which contain aromatic compounds of the general formula (2) formed by hydrolyzing and decarboxylating aromatic cyano compounds represented by the general formula (1) under the condition having sulfuric acid containing at a concentration in the range of 80 to 98 weight %.

[0047] When the reactions use sulfuric acid, the reaction vessel in popular use which is made of glass or lined with glass is adopted. A reaction vessel which is coated as with a fluorocarbon resin may be used instead.

[0048] The reaction vessel is preparatorily charged with an aqueous sulfuric acid solution containing sulfuric acid at a concentration in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight %. If the concentration of the aqueous sulfuric acid solution to be used falls short of 80 weight %, the shortage will be at a disadvantage in not only degrading the reaction speed but also inducing corrosion of the reaction vessel. If it exceeds 98 weight %, the excess will be at a disadvantage in decreasing the speed of the formation of 4-amino-2,3,5,6-tetrafluorobenzoic acid which is the precursor of 2,3,5,6-tetrafluoroaniline and consequently lowering the speed of the formation of 2,3,5,6-tetrafluoroaniline.

[0049] The reaction temperature is in the range of 50 to 180°C, preferably in the range of 60 to 170°C, and more preferably in the range of 70 to 160°C. If this temperature falls short of 50°C, the shortage will be at a disadvantage in lowering the speed of the reaction. Conversely, if the temperature exceeds 180°C, the excess will be at a disadvantage in lowering the selectivity of the reaction.

[0050] The reactions of hydrolysis and decarboxylation are generally carried out by charging the reaction vessel with the aqueous sulfuric acid solution and adding thereto the raw material, i.e. 4-amino-2,3,5,6-tetrafluorobenzonitrile. The addition of the raw material may be made all at once or sequentially. The sequential addition of the raw material is favorable because the reactions enjoy high selectivity and the reaction vessel is prevented from corrosion. When the

raw material is sequentially added, the speed of the addition may be properly selected. Favorably, this addition is made at a rate in the range of 0.1 to 20 weight parts, preferably in the range of 1 to 10 weight parts, per hour based on 100 weight parts of the charged aqueous sulfuric acid solution.

[0051] The expression "forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently" as used herein means that the molar ratio of the aromatic compound formed in the reaction vessel is not less than 85 mol %, preferably 90 mol %, and particularly preferably 95 mol %, based on the initial amount of the aromatic cyano compound represented by the formula (1). If the molar ratio falls short of 85 mol %, the shortage will be at a disadvantage in inducing the reaction vessel made of glass to sustain corrosion. After the aromatic compound represented by the general formula (2) has been formed, the product can be distilled with water azeotropically.

[0052] Favorably, the concentration of the acid substance in the aqueous medium prior to the azeotropic distillation is adjusted, as occasion demands, to a level falling short of 58 weight %, further to not more than 50 weight %, and further to not more than 40 weight %. Specifically, the adjustment of the concentration to the range mentioned above is favorably attained by using water.

[0053] When the aqueous medium is an alkaline substance, it suffices to have the concentration of the alkaline substance in the aqueous medium adjusted to a level within the range mentioned above. The adjustment of the concentration to the range mentioned above may be attained by incorporating into the aqueous medium a dilute acidic substance or alkaline substance in an amount enough for the adjustment.

[0054] Then, the azeotropic distillation which characterizes the present invention will be explained below.

[0055] From the reaction solution which is obtained as described above, the formed 2,3,5,6-tetrafluoroaniline is recovered by azeotropic distillation with water. In this case, the azeotropic distillation may be carried out after the reaction solution obtained in the presence of the aqueous medium has been mixed with water. The mixing of the reaction solution with water may be attained by adding water to the reaction solution, adding the reaction solution to a separate reaction vessel which has been charged in advance with water, or adding part of water to the reaction solution and feeding the resultant mixture to a separate reaction vessel. Generally, a method which comprises retaining the temperature of the water fed to a separate reaction vessel at a prescribed level and thereafter adding the reaction solution dropwise into the water is favorably adopted. As the aqueous medium, water or a mixture of water with an organic solvent miscible with water may be used. The use of water as the aqueous medium proves economical and advantageous in the sense that the azeotropic distillation can be performed under a favorable condition.

[0056] The amount of the water to be used for the mixing mentioned above is in the range of 0.1 to 10 weight parts, preferably in the range of 0.2 to 5 weight parts, and more preferably in the range of 0.3 to 3 weight parts, based on one weight part of the reaction solution. Generally, the water is preparatorily placed in a necessary amount collectively in a separate reaction vessel. After the azeotropic distillation has been started, the distillate is divided into water and 2,3,5,6-tetrafluoroaniline and the water expelled by this distillation is circulated to the reaction solution.

[0057] The azeotropic distillation is carried out with the temperature of the distillate in the reaction vessel (the so-called azeotropic temperature) fixed at a level in the range of 80 to 150°C, preferably in the range of 90 to 130°C. Though the pressure proper for this distillation may be either normal pressure or reduced pressure, the normal pressure proves more favorable.

[0058] The azeotropic distillation performed as described above can be likewise applied to the reaction solution which is obtained in and after the latter step of the process of the first aspect of this invention.

[0059] Now, this invention will be described below with reference to one example thereof, i.e. the procedure wherein the aqueous medium contains an alkaline substance, 4-amino-2,3,5,6-tetrafluorobenzonitrile is used as the aromatic cyano compound represented by the general formula (1), and 2,3,5,6-tetrafluoroaniline is produced as the aromatic compound represented by the general formula (2).

[0060] This invention concerns a process which comprises a step of hydrolyzing 4-amino-2,3,5,6-tetrafluorobenzonitrile under a condition containing an alkaline substance as the aqueous medium thereby obtaining 4-amino-2,3,5,6-tetrafluorobenzoic acid and/or a salt thereof (such as, for example, a sodium salt when the alkaline substance is sodium hydroxide) (hereinafter, indicated as 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt)), a step of decarboxylating the compound by the reaction of decarboxylation, and finally a step of recovering the formed 2,3,5,6-tetrafluoroaniline by azeotropic distillation with water.

[0061] The alkaline substance to be used in the step for hydrolysis mentioned above does not need to be particularly discriminated but is only required to be capable of hydrolyzing 4-amino-2,3,5,6-tetrafluorobenzonitrile and consequently forming 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt). Alkali metal salts, alkaline earth metal salts, and amines, for example, may be used as the alkaline substance. As concrete examples of the alkali metal salts, sodium hydroxide, potassium hydroxide, sodium carbonate, potassium carbonate, sodium hydrogen carbonate, and potassium hydrogen carbonate may be cited. As concrete examples of the alkaline earth metal salts, calcium hydroxide and calcium carbonate may be cited. The use of sodium hydroxide, among them, proves particularly advantageous by reason of economy. The combined use of sodium hydroxide and calcium hydroxide proves favorable from the viewpoint of preventing

the reaction vessel from corrosion. As concrete examples of the amines, alkyl amines such as dimethyl amine, trimethyl amine, ethyl amine, diethyl amine, triethyl amine, butyl amine, dibutyl amine, and tributyl amine and pyridine and quinoline may be cited. These alkaline substances may be used either singly or in the form of a combination of two or more members.

[0062] The amount of the alkaline substance to be used is in the range of 0.1 to 20 weight parts, preferably in the range of 0.3 to 10 weight parts, and more preferably in the range of 0.5 to 5 weight parts, based on one weight part of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile. If the amount of the alkaline substance to be used is excessive, the excess will be at a disadvantage in inducing the raw material to undergo a reaction for halogen substitution and lowering the selectivity of the reactions. If the amount is unduly small, the shortage will be at a disadvantage in preventing the reactions from proceeding smoothly.

[0063] The reaction of hydrolysis is properly carried out in an aqueous medium. As the aqueous medium, water may be used alone or in combination with a solvent miscible with water. As the solvent of this nature, alcohols, aprotic polar solvents, ketones, and esters can be used. As concrete examples of the alcohols, methanol, ethanol, n-propanol, isopropanol, ethylene glycol, and propylene glycol may be cited. As concrete examples of ketones, acetone, methylethyl ketone, and methyl isobutyl ketone may be cited. As concrete examples of esters, acetic esters such as ethyl acetate, propyl acetate, and butyl acetate may be cited. As concrete examples of aprotic polar solvents, dimethyl formamide (DMF), dimethyl sulfoxide (DMSO), and n-methyl pyrrolidone may be cited.

[0064] The amount of the aqueous medium to be used is in the range of 1 to 50 weight parts, preferably in the range of 2 to 30 weight parts, and more preferably in the range of 3 to 10 weight parts, based on one weight part of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile. If this amount is unduly large, the excess will be at a disadvantage in degrading the productivity of the target compound. If the amount is unduly small, the shortage will be at a disadvantage in preventing the reactions from advancing smoothly.

[0065] The reaction temperature is in the range of 20 to 200°C, preferably in the range of 30 to 150°C, and more preferably in the range of 40 to 100°C. If the reaction temperature is excessively high, the excess will be at a disadvantage in increasing secondary products due to the reaction of halogen substitution of the raw material and consequently lowering the selectivity of the target compound. Conversely, if the reaction temperature is excessively low, the shortage will be at a disadvantage in preventing the reactions from advancing at an economically sufficient speed.

[0066] The present process, because of the use of an alkaline substance, conspicuously allays the corrosion of the reaction vessel as compared with the conventional process which uses an acidic substance.

[0067] Now, the step of decarboxylation will be explained below. This is the step of performing the reaction of decarboxylation of the 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt) formed by the reaction of hydrolysis.

[0068] The reaction of decarboxylation may be attained by directly heating the aqueous medium containing the 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt) formed by the reaction of hydrolysis. It may be otherwise fulfilled by adding for the reactions an alkaline substance different from the alkaline substance used at the step of hydrolysis. As concrete examples of the alkaline substance proper for the addition, those alkaline substances enumerated above may be cited. Among other alkaline substances mentioned above, the alkaline earth metal salts prove advantageous because they allow the reactions to proceed more smoothly and prevent the reaction vessel from being corroded with the fluorine ions formed by the secondary reaction involved in the step of decarboxylation. The amount of the alkaline earth metal salt to be used is in the range of 0.01 to 2 weight parts, preferably in the range of 0.02 to 1 weight part, and more preferably in the range of 0.03 to 0.5 weight part, based on one weight part of the 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt). If the amount so used is unduly large, the excess will be at a disadvantage in increasing the secondary products due to the reaction of halogen substitution of the raw material and consequently lowering the selectivity of the target compound. Conversely, if this amount is unduly small, the shortage will be at a disadvantage in precluding fulfillment of the effect mentioned above.

[0069] The decarboxylation may be effected after the alkaline substance existing in the aqueous medium has been partially or completely neutralized by the addition of an acidic substance to the aqueous medium.

[0070] The acidic substance mentioned above may be either an inorganic acid or an organic acid. As concrete examples of the inorganic acid, hydrochloric acid, sulfuric acid, and nitric acid may be cited. As concrete examples of the organic acid, formic acid, acetic acid, propionic acid, and butyric acid may be cited. By reason of economy, sulfuric acid is used particularly favorably among them. The amount of the acidic substance to be used is in the range of 0.1 to 2 equivalents, preferably in the range of 0.3 to 1.5 equivalents, and more preferably in the range of 0.5 to 1 equivalent, based on the weight of the alkaline substance. If this amount is unduly small, the shortage will be at a disadvantage in preventing the target compound from being obtained at a sufficiently high speed of reaction. Conversely, if the amount is unduly large, the excess will be at a disadvantage in compelling the reaction of decarboxylation to proceed under an acidic condition, increasing the secondary products due to the reaction of halogen substitution of the raw material, and consequently inducing corrosion of the reaction vessel due to the generation of hydrogen fluoride.

[0071] The reaction of decarboxylation may be performed under either normal pressure or increased pressure. Favorably, it is carried out under increased pressure such as, for example, a pressure in the approximate range of 0.1 to

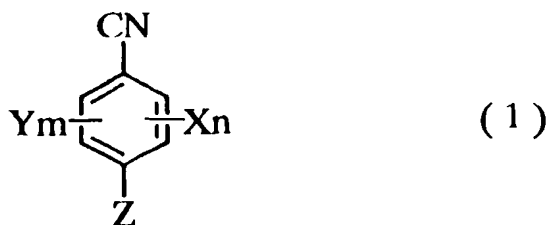
5 MPa because the reactions proceed more smoothly under the increased pressure. When the reactions are performed under the increased pressure, they may be effected by using a pressure-resistant reaction vessel and keeping a closed system therein by accumulating a gas in the reaction vessel. The reactions may be otherwise carried out by partially extracting from the reaction vessel the gas having as its main component the carbon dioxide gas generated by the reactions, thereby keeping the pressure in the reaction vessel at a fixed level.

[0072] The reaction temperature is in the range of 30 to 200°C, preferably in the range of 50 to 180°C, and more preferably in the range of 70 to 160°C. If the reaction temperature is unduly high, the excess will be at a disadvantage in increasing the secondary products due to the reaction of halogen substitution of the raw material and consequently entailing such problems as corrosion of the reaction vessel due to the generation of hydrogen fluoride. Conversely, if the reaction temperature is unduly low, the shortage will be at a disadvantage in preventing the reactions from proceeding smoothly.

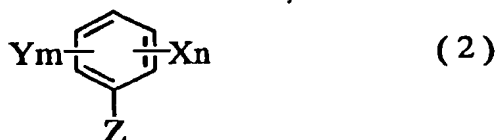
[0073] The step of hydrolysis and the step of decarboxylation mentioned above may be performed in one and the same reaction vessel or in different reaction vessels. As the reaction vessel, the reaction vessel in common use which is made of carbon steel or stainless steel may be used.

[0074] The molar ratio of the aromatic compound to be formed in the reaction vessel engaging in azeotropic distillation, similarly to the reactions using an aqueous solution as an acidic substance, means that the molar ratio of the aromatic compound of the general formula (2) to be formed reaches a level of not less than 85 mol %, preferably 90 mol %, and more preferably 95 mol %, based on the initial amount of the aromatic cyano compound represented by the formula (1). The step of azeotropic distillation is the same as when the acidic substance is used.

[0075] The third aspect of this invention is in the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the hydrolysis and decarboxylation in multiple steps and effecting the recovery of the formed aromatic compound from the reaction solution by azeotropic distillation with water.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by -N(R¹)(R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 ≤ m + n ≤ 4.)



(wherein the symbols have the same meanings as in the general formula (1).)

[0076] The third invention is directed to a process which comprises hydrolyzing and decarboxylating the aromatic cyano compound represented by the general formula (1) in multiple steps including a former step and a latter step using different reaction conditions in the presence of the acidic substance thereby producing the aromatic compound represented by the general formula (2) and subsequently recovering the formed aromatic compound from the reaction solution by azeotropic distillation with water. Since the reactions are performed in at least two steps by using the acidic substance, the secondary production of such a corrosive substance as hydrofluoric acid can be repressed. Further, since the target compound is recovered by azeotropy, it is made possible to prevent the reaction vessel from being corroded during the course of the azeotropy and enable the target compound to be produced in a high yield.

[0077] The compounds represented by the general formulas (1) and (2) mentioned above are the same as those of

the first aspect of this invention. Further, the "acidic substance" to be used and the conditions for performing "the reactions of hydrolysis and decarboxylation in multiple steps including a former step and a latter step using different reaction conditions" are the same as those which have been covered in the foregoing description of the first aspect of the invention. In the present invention, the molar ratio of the aromatic compound of the formula (2) formed in the reaction vessel is not less than 85 mol %, preferably 90 mol %, and more preferably 95 mol %, based on the initial amount of the aromatic cyano compound represented by the formula (1). If this molar ratio falls short of 85 mol %, the shortage will be at a disadvantage in inducing the reaction vessel of glass used for the reactions of hydrolysis and decarboxylation or in the step of azeotropy to sustain corrosion. The conditions for azeotropically distilling the formed aromatic compound are the same as those which are covered by the foregoing description of the second aspect of the invention.

EXAMINATIONS

[0078] Now, this invention will be described more specifically with reference to working examples adduced hereinafter for illustration.

<Referential Example 1: Synthesis of 4-amino-2,3,5,6-tetrafluorobenzonitrile>

[0079] A 500ml four-neck flask provided with a stirrer, a thermometer, and a cooling tube was charged with 75 g (389 mmols) of pentafluorobenzonitrile, 225 ml of n-propyl acetate, 79.5 g of an aqueous 25% ammonia solution (1.165 mols as ammonia), and 0.375 g of tetrabutyl ammonium bromide. The contents of the reaction vessel were left reacting at 25°C for one hour and further reacting at 50°C for five hours. When the reaction solution obtained after completion of the reaction was analyzed by gas chromatography, the conversion ratio of pentafluorobenzonitrile was found to be 100% and the yield of the target component, 4-amino-2,3,5,6-tetrafluorobenzonitrile to be 94%.

[0080] The n-propyl acetate layer containing 4-amino-2,3,5,6-tetrafluorobenzonitrile was separated and washed twice with 100 g of an aqueous 10 weight % sodium sulfate solution to remove the ammonium fluoride contained in the layer. Subsequently, the n-propyl acetate layer was heated to expel the n-propyl acetate by distillation and obtain 73.5 g of 4-amino-2,3,5,6-tetrafluorobenzonitrile (purity 94%) (yield 93.6%). The product contained 4.5 g (6%) of 2-amino-3,4,5,6-tetrafluorobenzonitrile as an impurity.

Example 1

(Former step reactions)

[0081] A 200ml four-neck flask made of glass and provided with a stirrer, a thermometer, and a cooling tube was charged with 120 g of an aqueous 90 weight % sulfuric acid solution and heated till the internal temperature thereof reached 110°C, with the solution kept stirred. Subsequently, 50 g of the solid obtained in Referential Example 1 (having a 4-amino-2,3,5,6-tetrafluorobenzonitrile content of 94%) was fed at a feed rate of 4 g/h to an aqueous 90 weight % sulfuric acid solution kept at 110°C. The concentration of sulfuric acid in the reaction vessel during the former step reactions was in the range of 90 to 94 weight %. After the feeding was completed, the reaction was further continued for two hours. When the reaction solution was sampled and analyzed by liquid chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was 100 mol % and the products formed in the reaction solution were found to be as follows.

4-Amino-2,3,5,6-tetrafluorobenzamide	65 mol %
4-Amino-2,3,5,6-tetrafluorobenzoic acid	10 mol %
2,3,5,6-Tetrafluoroaniline	20 mol %

(Latter step reactions)

[0082] By adding 22 g of water to the reaction solution mentioned above, the concentration of the aqueous sulfuric acid solution was adjusted to 80 weight % and the reaction was continued for 15 hours. The concentration of sulfuric acid in the reaction vessel during the latter step reactions was 80 weight %. When the reaction solution obtained after completion of the reaction was sampled and analyzed by liquid chromatography, the yield of 2,3,5,6-tetrafluoroaniline was found to be 98 mol %.

(Step of azeotropy)

[0083] A 500 ml four-neck flask made of glass and provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube was charged with 300 ml of water and heated to 100°C, with the water therein as kept stirred, to retain a state of reflux in the reaction vessel.

[0084] The reaction solution obtained in the step of hydrolysis and decarboxylation was placed in the dropping funnel, retained at 110°C by means of an electric heater, and added dropwise into the flask over a period of one hour, and subjected to azeotropic distillation to expel 2,3,5,6-tetrafluoroaniline into the water separating tube.

[0085] The upper layer of the distillate collecting in the water separating tube was water and the lower layer thereof was 2,3,5,6-tetrafluoroaniline. The expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours, with the distilled water circulated continuously into the flask.

[0086] From the water separating tube, 39.4 g of 2,3,5,6-tetrafluoroaniline was obtained. When this compound was analyzed by gas chromatography, the purity thereof was found to be 99.5%. The total yield in the step of hydrolysis and decarboxylation and the step of azeotropic distillation was found to be 96.0%. When the inner walls of the reaction vessels used for the hydrolysis and decarboxylation and for the azeotropic distillation were visually inspected, no discernible sign of corrosion was detected.

(Determination of annual ratio of corrosion)

[0087] The reaction vessels used in the reactions mentioned above were measured for annual ratio of corrosion. The reactions of hydrolysis and decarboxylation were carried out by following the procedure described above while using a 500ml separable flask made of stainless steel lined with a fluorocarbon resin in place of a flask made of glass, having a glass test piece (pestle type, made by NGK Insulators Ltd., and sold under the product code of "GIL-400") immersed near the interface, and tripling the amounts of the aqueous sulfuric acid solution and the solid, and the speed of addition of the solid. This reaction was performed up to two repetitions. When the test piece which had undergone the reaction three times was taken out and tested for annual ratio of corrosion in accordance with the following formula, the ratio was found to be 0.02 mm/year.

Annual ratio of corrosion (mm/year)

$$\{(W_0 - W_1)/D\}/S \times \{[24(\text{hr/day}) \times 365(\text{days/year})]/T\}$$

wherein

W_0 : weight of test piece before the test (mg)

W_1 : weight of test piece after the test (mg)

D: specific gravity of test piece (mg/mm³)

S: surface area of test piece (mm²)

T: duration of test (hr)

Example 2

(Reactions of hydrolysis and decarboxylation)

[0088] A 200ml four-neck flask made of glass and provided with a stirrer, a thermometer, and a cooling tube was charged with 100 g of an aqueous 90% sulfuric acid solution and heated till the internal temperature thereof reached 100°C, with the solution as kept stirred. Then, 50 g of the solid (having a 4-amino-2,3,5,6-tetrafluorobenzonitrile content of 94%) obtained in Referential Example 1 was fed at a feed rate of 4 g/h to an aqueous 90% sulfuric acid solution, with the solution as kept stirred. After the supply was completed, the reaction was continued further for two hours. When the reaction solution was sampled and analyzed by liquid chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was found to be 98 mol % and the products formed in the reaction solution were found to be as follows.

4-Amino-2,3,5,6-tetrafluorobenzamide	55 mol %
4-Amino-2,3,5,6-tetrafluorobenzoic acid	10 mol %
2,3,5,6-Tetrafluoroaniline	8 mol %

[0089] The concentration of the aqueous sulfuric acid solution was adjusted to 80% by adding 19 g of water to the reaction solution and also heated to 120°C. The ensuing reaction was continued for 15 hours. When the reaction solution obtained after completion of the reaction was sampled and analyzed by liquid chromatography, the yield of 2,3,5,6-tetrafluoroaniline was found to be 98%.

(Step of azeotropy)

[0090] A 500ml four-neck flask made of glass and provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube was charged with 300 ml of water and heated to 100°C, with the water as kept stirred, to retain a state of reflux in the flask.

[0091] The reaction solution obtained in the step of hydrolysis and decarboxylation was placed in the dropping funnel, retained at 110°C by means of an electric heater, and added dropwise into the flask over a period of one hour, and subjected to azeotropic distillation to expel 2,3,5,6-tetrafluoroaniline into the water separating tube.

[0092] The upper layer of the distillate collecting in the water separating tube was water and the lower layer thereof was 2,3,5,6-tetrafluoroaniline. The expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours, with the distilled water circulated continuously into the flask.

[0093] From the water separating tube, 39.7 g of 2,3,5,6-tetrafluoroaniline was obtained. When this compound was analyzed by gas chromatography, the purity thereof was found to be 99.8%.

[0094] The total yield in the step of hydrolysis and decarboxylation and the step of azeotropic distillation was found to be 97.1 %. When the inner walls of the reaction vessels used for the hydrolysis and decarboxylation and for the azeotropic distillation was visually inspected, no discernible sign of corrosion was detected.

(Determination of annual ratio of corrosion)

[0095] When the reaction vessels used in the reaction of hydrolysis and the reaction of decarboxylation were measured for annual ratio of corrosion by following the procedure of Example 1, the ratio was found to be 0.03 mm/year.

Examples 3 to 8

[0096] The hydrolysis and decarboxylation and the azeotropic distillation were performed by following the procedure of Example 1 while changing the concentrations of sulfuric acid, the reaction temperatures, and the duration of reaction in the former step reactions and the latter step reactions as shown in Table 1. The conversion ratio of the raw material (4-amino-2,3,5,6-tetrafluorobenzonitrile), the amount of TFA (2,3,5,6-tetrafluoroaniline) formed (mol%), the presence or absence of corrosion on the reaction vessels used for the reaction of analysis and the reaction of decarboxylation, the yields (yields at the steps of hydrolysis and decarboxylation), and the annual ratio of corrosion were as shown in Table 1. The results of Examples 1 and 2 are collectively shown in the table 1.

Table 1

Example	Former step reactions				Amount of TPA (mol %)	Former step reactions		Yield of TPA (mol %)	Corrosion determined	Annual corrosion ratio (mm/year)	
	Temp. (°C)	Conc. of H ₂ SO ₄ (%)	Duration (hr)	conversion ratio(mol %)		Temp. (°C)	Conc. of H ₂ SO ₄ (%)				
1	110	90	15	100	20	110	80	15	98	none	0.02
2	100	90	15	98	8	120	80	15	98	none	0.03
3	90	95	17	95	7	110	80	16	97	none	0.01
4	100	90	18	100	8	120	90	14	98	none	0.03
5	120	90	13	100	31	120	80	8	97	none	0.05
6	110	85	16	100	25	120	85	10	99	none	0.04
7	80	95	12	90	3	120	85	20	98	none	0.02
8	70	95	15	85	2	110	80	21	97	none	0.01
Comparative Example 1	140	60	6	96	82.5	-	-	-	-	found	0.30

Example 9

(Step of hydrolysis and decarboxylation)

[0097] A 200ml four-neck flask provided with a stirrer, a thermometer, and a cooling tube was charged with 120 g of an aqueous 85% sulfuric acid solution, heated to 130°C, and thereafter retained at this temperature. Into the flask, 40 g of the 4-amino-2,3,5,6-tetrafluorobenzonitrile (94% in purity) obtained in Referential Example 1 was added in a molten state dropwise at a rate of 4 g/h over a period of 10 hours. After the dropwise addition was completed, the reaction was further continued for eight hours. When the reaction solution obtained at the end of the reaction was analyzed by liquid chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was found to be 100% and the yield of the target product, 2,3,5,6-tetrafluoroaniline, was found to be 98%.

(Step of azeotropy)

[0098] In a 200ml four-neck flask provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube, 50 g of water was placed, heated to 100°C, and retained at this temperature. Then, the reaction solution obtained at the steps mentioned above was transferred into the dropping funnel adapted to retain temperature by heating and dropped therefrom at a rate of 120 g/hr. The temperature of heating in the reaction vessel was continuously elevated so as to expel the target product, 2,3,5,6-tetrafluoroaniline by distillation into the water separating tube at 100°C during the initial stage of the distillation and at 140°C at the time of completion of the distillation. The 2,3,5,6-tetrafluoroaniline expelled by distillation was withdrawn into a receptacle and the water formed by distillation was returned to the four-neck flask. Thus the expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours. As a result, 32 g of 2,3,5,6-tetra fluoroaniline having a purity of 98.5% was obtained. The yield was 98.5%.

[0099] When the inner walls of the reaction vessels used for the hydrolysis and the decarboxylation and for the azeotropic distillation were visually inspected, no discernible sign of corrosion was detected on any of the reaction vessels. When the reaction vessels used for the hydrolysis and the decarboxylation were measured for annual ratio of corrosion, the ratio was found to be 0.09 mm/year.

Comparative example 1

[0100] 2,3,5,6-Tetrafluoroaniline was produced from 4-amino-2,3,5,6-tetrafluorobenzonitrile. To be specific, in a 200ml four-neck flask provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube, 100 g of 60% sulfuric acid was placed and heated to 140°C. To the hot sulfuric acid, 36 g of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile (having a purity of 94% and containing 6% of 2-amino-3,4,5,6-tetrafluorobenzonitrile as an impurity) was added dropwise at a rate of 6 g/hr. The 2,3,5,6-tetrafluoroaniline which was formed by the reaction was expelled by azeotropy with water, guided into the water dropping tube, and separated from the water. The reaction was continued for six hours while the reaction vessel was supplied with the same amount of water as expelled by distillation. After the completion of the reaction, the conversion ratio of the raw material determined by gas chromatography was found to be 96 mol %. When the 2,3,5,6-tetrafluoroaniline expelled by distillation was analyzed, the purity was found to be 95.3% and the yield to be 82.5%.

[0101] When the reaction vessels were visually inspected, the inner walls thereof were found to sustain a discernible corrosion probably induced by hydrogen fluoride. The annual-ratio of corrosion was 0.3 mm/year.

Example 10

(Step of hydrolysis)

[0102] In a 100ml four-neck flask provided with a stirrer, a thermometer, and a cooling tube, 14.7 g of the solid (having a 4-amino-2,3,5,6-tetrafluorobenzonitrile content of 94%) obtained in Referential Example 1 was placed and 80 g of an aqueous 10% sodium hydroxide solution was further added thereto and they were allowed to react at 50°C for eight hours. When the reaction solution obtained at the end of the reaction was analyzed by gas chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was found to be 100% and the yield of the target compound, 4-amino-2,3,5,6-tetrafluorobenzoic acid, was found to be 98%.

(Step of decarboxylation)

[0103] A 100ml autoclave was charged with the reaction solution obtained in the step of hydrolysis plus 9.8 g of concentrated sulfuric acid (equivalent to the sodium hydroxide used in the step of hydrolysis). With the inner temper-

ature of the autoclave elevated to 130°C, and the inner pressure of the reaction vessel retained at 0.2 MPa, the reaction was carried out for eight hours. When the reaction solution obtained after the completion of the reaction was analyzed by gas chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzoic acid was found to be 100%, and the yield of 2,3,5,6-tetrafluoroaniline was found to be 95%.

(Step of azeotropy)

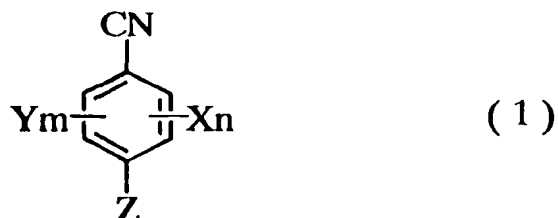
[0104] In a 200ml four-neck flask provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube, the reaction solution obtained in the step of decarboxylation was placed, heated to 100°C, and retained at this temperature. With the water placed in the dropping funnel added dropwise thereto, the temperature of the heating of the flask was elevated so as to expel the target compound, 2,3,5,6-tetrafluoroaniline by distillation into the water separation tube. The expulsion of 2,3,5,6-tetrafluoroaniline by distillation was attained at 100°C in a reaction vessel during the initial stage of distillation and at 140°C at the time of completing the distillation.

[0105] With the distilled 2,3,5,6-tetrafluoroaniline withdrawn into a receptacle and the distilled water returned to the four-neck flask, the expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours. As a result, 11.3 g of 2,3,5,6-tetrafluoroaniline having a purity of 98.5% was obtained.

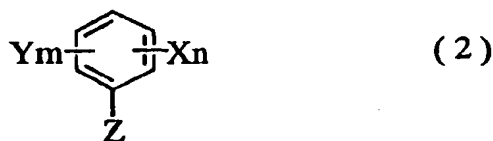
[0106] The total yield in the step of hydrolysis and decarboxylation and in the step of azeotropy was 94.5%. When the interiors of the reaction vessels used for the hydrolysis and the decarboxylation and for the azeotropy were visually inspected, no discernible sign of corrosion was detected in any of the reaction vessels. The annual ratio of corrosion of the reaction vessels used for the step of hydrolysis and decarboxylation was 0.02 mm/year.

Claims

1. In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, **characterized by** performing the reactions of hydrolysis and decarboxylation in multiple steps



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by -N(R¹)(R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 ≤ m + n ≤ 4.)

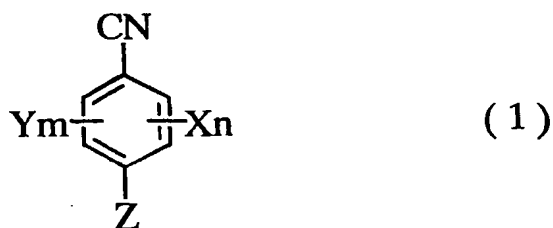


(wherein the symbols have the same meanings as in the general formula (1).)

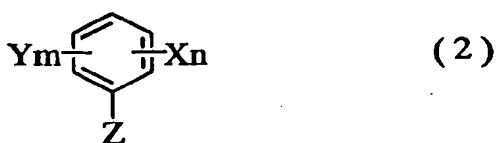
2. A method according to claim 1, wherein the conversion ratio of the aromatic cyano compound represented by the general formula (1) is fixed at a level of not less than 40 mol % and the molar ratio of the formation of the aromatic compound represented by the general formula (2) to the initial amount of the aromatic cyano compound represented by the formula (1) is fixed at a level of not more than 80 mol % in a former step reaction in said multiple steps respectively, and subsequently the reactions of hydrolysis and decarboxylation are terminated in and after

a latter step reactions in said multiple steps.

3. A method according to claim 1, wherein the reactions in the former step and the latter step in said multiple steps are carried out on the conditions of lowering the concentration of said acidic substance and/or increasing the reaction temperature.
4. A method according to claim 3, wherein said acidic substance is an aqueous sulfuric acid solution.
5. A method according to claim 1, wherein said aromatic cyano compound is 4-amino-2,3,5,6-tetrahalogenobenzonitrile and said aromatic compound is 2,3,5,6-tetrahalogenoaniline.
6. A method according to claim 1, wherein said reactions of hydrolysis and decarboxylation are carried out in the presence of sulfuric acid in a reaction vessel made of glass or lined with glass.
7. A method for the production of an aromatic compound, **characterized by** forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently recovering the obtained aromatic compound from the reaction solution by azeotropic distillation with water.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by -N(R¹)(R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 ≤ m + n ≤ 4.)

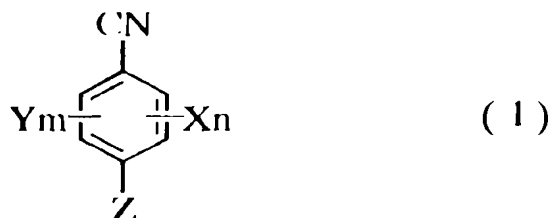


(wherein the symbols have the same meanings as in the general formula (1).)

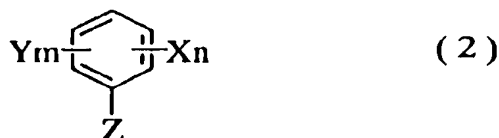
8. A method according to claim 7, wherein said aqueous medium contains an acidic substance and the concentration of the acidic substance in said aqueous medium is in the range of 80 to 98 weight %.
9. A method according to claim 8, wherein said acidic substance is sulfuric acid.
10. A method according to claim 7, wherein the molar ratio of the formation of the aromatic compound represented by the general formula (2) is not less than 85 mol % to the initial amount of the aromatic cyano compound represented by the general formula (1).
11. A method according to claim 7, wherein said aromatic cyano compound is 4-amino-2,3,5,6-tetrahalogenobenzonitrile and said aromatic compound is 2,3,5,6-tetrahalogenoaniline.
12. A method according to claim 7, wherein said aqueous medium contains an alkaline substance.
13. A method according to claim 7, wherein said aromatic cyano compound is 4-amino-2,3,5,6-tetrafluorobenzonitrile

and said aromatic compound is 2,3,4,6-tetrafluorobenzonitrile.

14. In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, **characterized by** performing the hydrolysis and decarboxylation in multiple steps and effecting the recovery of the formed aromatic compound from the reaction solution by azeotropic distillation with water.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen containing group represented by $\text{N(R}^1\text{)} \text{N(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m + n \leq 4$.)



(wherein the symbols have the same meanings as in the general formula (1).)

15. A method according to claim 14, wherein a former step reactions in said multiple steps are carried out under the condition of an acidic state in a concentration in the range of 80 to 98 weight % to react an aromatic cyano compound represented by the general formula (1) and subsequently a latter step reactions in said multiple steps are carried out under the condition of having the concentration of said acidic substance lowered by a level in the range of 5 to 50 weight % and/or elevating the reaction temperature by a level in the range of 5 to 30°C.
16. A method according to claim 14, wherein the molar ratio of the formation of the aromatic compound represented by the formula (2) to the aromatic cyano compound represented by the formula (1) in said reaction solution is not less than 85 mol %.
17. A method according to claim 14, wherein said acidic substance is an aqueous sulfuric acid solution.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 0730

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D, X	<p>DATABASE WPI Section Ch, Week 199651 Derwent Publications Ltd., London, GB; Class B05, AN 1996-514953 XP002197151 & JP 08 268979 A (NIPPON SHOKUBAI CO LTD), 15 October 1996 (1996-10-15) * abstract *</p>	7-13	<p>C07C209/68 C07C211/52</p>
A	<p>----- EP 0 497 213 A (ISHIHARA SANGYO) 5 August 1992 (1992-08-05) * claims; examples *</p>	1, 14	
A	<p>----- EP 0 415 595 A (ICI) 6 March 1991 (1991-03-06) * claims; examples *</p>	1, 7, 14	
			<p>TECHNICAL FIELDS SEARCHED (Int.Cl.7)</p>
			C07C
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		23 April 2002	Zervas, B
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

EPO FORM 1603 03 82 (P4/C31)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 02 25 0730

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are also contained in the European Patent Office EDP file on.
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23 04 2002

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US006521794B2

(12) **United States Patent**
Hirota

(10) **Patent No.:** **US 6,521,794 B2**
(45) **Date of Patent:** **Feb. 18, 2003**

(54) **METHOD FOR PRODUCTION OF
AROMATIC COMPOUNDS**

(75) Inventor: **Kouichi Hirota**, Kobe (JP)

(73) Assignee: **Nippon Shokubai Co., Ltd.** (JP)

(*) Notice: Subject to any disclaimer, the term of this
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(52) **U.S. Cl.** **564/442**; 564/441; 564/124;
564/129; 560/456

(58) **Field of Search** 564/442, 441,
564/124, 129; 562/456

(56) **References Cited**

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Primary Examiner—Samuel Barts

(74) *Attorney, Agent, or Firm*—Mathews, Collins,
Shepherd & McKay, P.A.

(57) **ABSTRACT**

For the production of an aromatic compound by hydrolyzing and decarboxylating a corresponding aromatic cyano compound in the presence of an acidic substance, this invention provides a method for the production of the aromatic compound, characterized by carrying out the reactions of hydrolysis and decarboxylation in multiple steps. Particularly when the aromatic cyano compound contains a halogen, this method effectively prevents the reaction vessels from being corroded by the by-produced hydrogen halogenide and enables the target compound to be produced in a high yield.

17 Claims, No Drawings

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METHOD FOR PRODUCTION OF AROMATIC COMPOUNDS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method for the production of aromatic compounds and more particularly to a method for the production of aromatic compounds by using a halogen-containing aromatic cyano compound as a raw material, performing hydrolysis and decarboxylation on the raw material without inducing corrosion of the reaction vessel to obtain a corresponding aromatic compound aimed at with a high yield.

2. Description of Related Art

The tetrahalogenoanilines include important compounds which are used as intermediate raw materials for pharmaceutical preparations and agricultural pesticides. Methods for producing 2,3,5,6-tetrafluoroaniline are described in the official gazettes of JP-A-06-211,756 and JP-A-08-268,979, for example. The method described in the official gazette of JP-A-06-211,756 is claimed to obtain 2,3,5,6-tetrafluoroaniline by using a pentafluorobenzoic acid as a raw material and causing it to react with ammonia in an aqueous medium and consequently undergo amination and decarboxylation. It is described that the pentafluorobenzoic acid as the raw material can be obtained by hydrolyzing pentafluorobenzonitrile in an aqueous sulfuric acid solution and that though the aqueous reaction solution contains excess sulfuric acid and ammonium sulfate as a reaction product besides the pentafluorobenzoic acid, the obtained pentafluorobenzoic acid can be used directly in its unmodified form without being washed with water in the reaction for the production of 2,3,5,6-tetrafluoroaniline.

Then, the method disclosed in the official gazette of JP-A-08-268,979 is claimed to obtain 2,3,5,6-tetrafluoroaniline by using 4-amino-2,3,5,6-tetrafluorobenzonitrile as a raw material, adding it together with water to an aqueous sulfuric acid solution thereby enabling the 2,3,5,6-tetrafluoroaniline formed consequently by hydrolysis and decarboxylation to be distilled with water by azeotropic distillation and meanwhile causing the reaction of hydrolysis and decarboxylation to proceed. Since the hydrofluoric acid which is formed by a secondary reaction corrodes reaction devices made of stainless steel or lined with glass, this method immediately distills the formed 2,3,5,6-tetrafluoroaniline azeotropically with water and feeds water to the reaction vessel for the purpose of keeping the concentration of sulfuric acid therein at a fixed level, with the result that the reaction a vessel is prevented from corrosion and the 2,3,5,6-tetrafluoroaniline is obtained in a high yield.

Generally, when a given reaction involves use of sulfuric acid, for example, the reaction vessel for this reaction is made of glass or lined with glass because the vessel would be destined to incur corrosion if it was made of iron or steel. The method disclosed in the aforementioned official gazette of JP-A-08-268,979 is directed at preventing a reaction vessel from corrosion, when the method uses 4-amino-2,3,5,6-tetrafluorobenzonitrile in a low purity as a raw material, however, the vessel undergoes discernible corrosion. When the raw material is subjected to a treatment for removal of impurities in advance, the treatment would be capable of preventing the vessel from corrosion but suffer disadvantage in adding to the number of steps for the process.

In a working example cited in the official gazette of JP-A-08-268,979, the 2,3,5,6-tetrafluoroaniline is reported

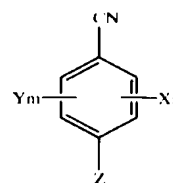
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to be obtained in a yield of 82.5%. Thus, the desirability of further enhancing the yield finds ready approval.

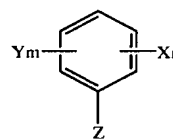
SUMMARY OF THE INVENTION

The present inventor, as a result of a detailed study on a path of synthesis of an aromatic amino compound obtained by the hydrolysis and decarboxylation of a halogen-containing aromatic cyano compounds and on a secondary product formed in the synthesis, has found that the occurrence of impurities can be repressed, the yield of the product can be enhanced, and the corrosion of a reaction vessel can be prevented by carrying out the reaction of hydrolysis and decarboxylation as divided into two discrete steps in using different conditions. As a result of further continuing a detailed study on the timing for effecting the distillation of the target product from the reaction system, he has discovered that the corrosion of the reaction vessel can be prevented and the target aromatic amino compound can be obtained in a high yield by performing the hydrolysis and decarboxylation in the presence of an aqueous medium thereby effecting formation of the aromatic amino compound and thereafter expelling the aromatic amino compound through azeotropic distillation with water. The present invention has been perfected based on the knowledge thus acquired. Specifically, this invention is aimed at providing the methods stated in the following items (1) to (3).

(1) In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the reactions of hydrolysis and decarboxylation in multiple steps.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $-\text{N}(\text{R}^1)(\text{R}^2)$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$.)

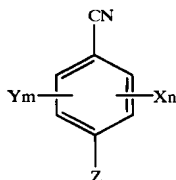


(wherein the symbols have the same meanings as in the general formula (1).)

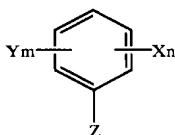
(2) A method for the production of an aromatic compound, characterized by forming an aromatic compound

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represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently recovering the obtained aromatic compound from the reaction solution by azeotropic distillation with water.

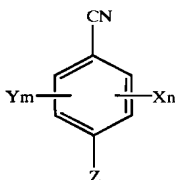


(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{—N(R}^1\text{)(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$.)



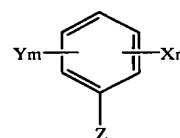
(wherein the symbols have the same meanings as in the general formula (1).)

(3) In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the hydrolysis and decarboxylation in multiple steps and effecting the recovery of the formed aromatic compound from the reaction solution by azeotropic distillation with water.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{—N(R}^1\text{)(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$.)

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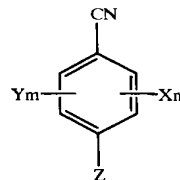


(wherein the symbols have the same meanings as in the general formula (1).)

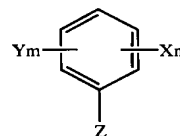
According to the method of this invention, by using a raw material such a halogen-containing aromatic compound as 4-amino-2,3,5,6-tetrahalogenobenzonitrile, it is made possible to produce such a corresponding aromatic compound as 2,3,5,6-tetrahalogenoaniline in a high yield. Even when the 4-amino-2,3,5,6-tetrahalogenobenzonitrile formed in low purity is hydrolyzed, decarboxylated, and azeotropically distilled particularly in the reaction vessel made of glass or lined with glass, the production of the aromatic compound can be attained in a high yield without inducing corrosion of the reaction vessel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The first aspect of this invention is in the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the reactions of hydrolysis and decarboxylation in multiple steps.



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{—N(R}^1\text{)(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$.)



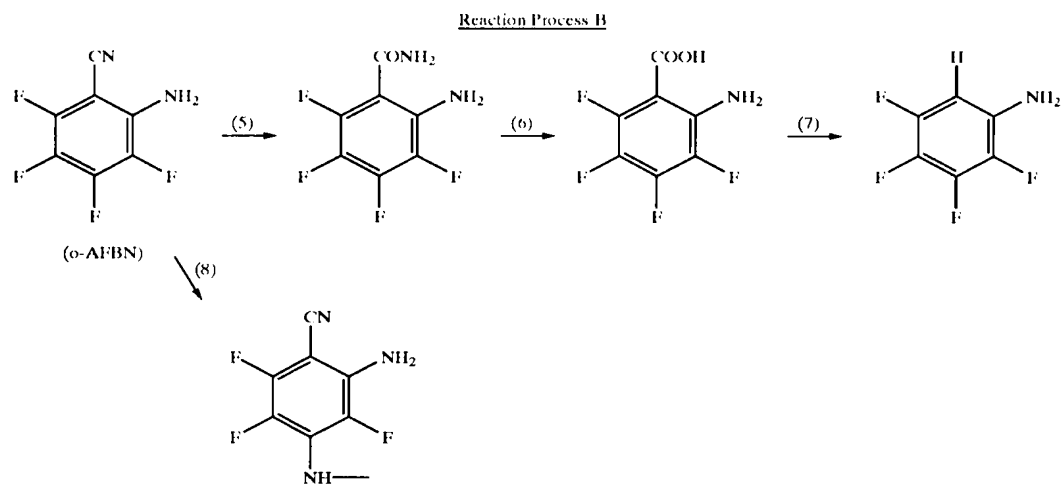
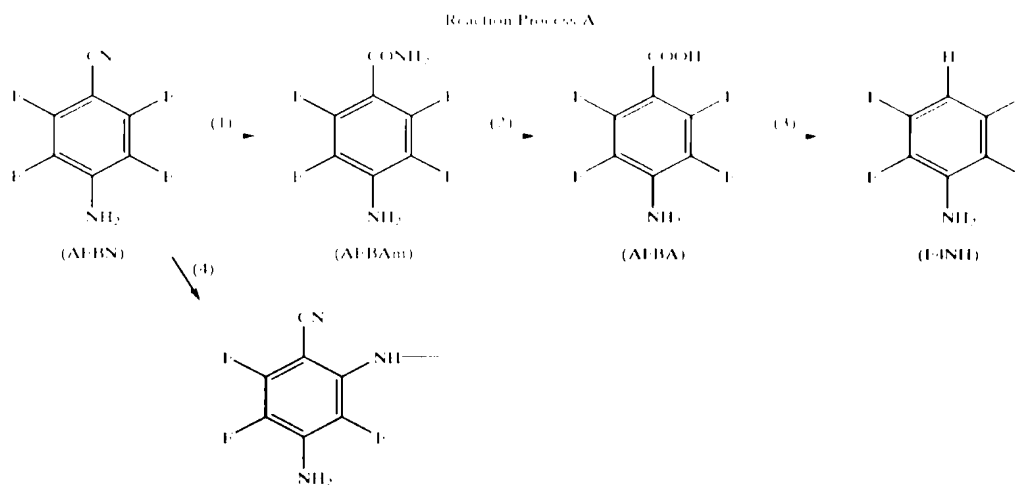
(wherein the symbols have the same meanings as in the general formula (1).)

When 4-amino-2,3,5,6-tetrafluorobenzonitrile of low purity is used as a raw material containing an aromatic cyano compound represented by the general formula (1), for example, the possibility of the reaction vessel being corroded with hydrogen fluoride will arise. By a study of the

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cause for this trouble, it has been found that the impurities contained in the raw material such as, for example, 2-amino-3,4,5,6-tetrafluorobenzonitrile is liable to cause such an origin of the trouble. From a further study on the relation of the trouble with corrosion, the inventor has acquired the following knowledge.

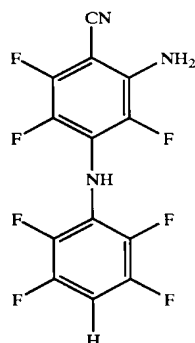
First, when 2,3,5,6-tetrafluoroaniline (F4NH) is produced by hydrolyzing and decarboxylating 2-amino-2,3,5,6-tetrafluorobenzonitrile (NFBN) with sulfuric acid, the reaction of hydrolysis and the reaction of decarboxylation are thought to proceed through a reaction process A which is composed of such steps (1) to (3) as shown below.



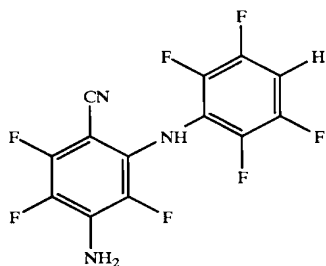
When the step (8) is passed, the substitution reaction occurring between the amino group of the target compound, 2,3,5,6-tetrafluoroaniline (F4NH), and the fluorine atom at the 4 position of 2-amino-3,4,5,6-tetrafluorobenzonitrile

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(o-AFBN) forms a compound represented by the following formula (3) and, at the same time, by-produces hydrogen fluoride.



When the raw material 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) passes the step (4) as a secondary reaction in the reaction process A, the relevant reaction forms a compound represented by the following formula (4) mentioned below and, at the same time, by-produces hydrogen fluoride. For, the step (4) causes the fluorine atom located at the ortho position of the cyano group of the raw material AFBN to react with the F4NH compound obtained at the step (3) to produce a compound represented by the following formula (4) and, at the same time, by-produce hydrogen fluoride. The speed of this secondary reaction is estimated to be greater in the step (8) than in the step (4). To be specific, the corrosion of the reaction vessel with the by-produced hydrogen fluoride gains in prominence as the impurities in the raw material grow in concentration.



Besides the elucidation described above, it has been found that when the process of hydrolysis and decarboxylation is performed in one step in the presence of an acidic substance under the condition using an aqueous sulfuric acid solution of a concentration of 80 weight %, for example, the reactions of the step (1) and the step (5) proceed much faster than the reactions of the step (4) and the step (8) and that the reactivity with fluorine atoms is degraded because the amino group forms a sulfate under the condition. As a result, the secondary production of hydrogen fluoride is repressed and the corrosion of the reaction vessel is effectively prevented.

To continue the explanation, the compound to be formed through the steps (4) and (8) in the reaction processes A and B mentioned above possibly assumes a structure other than the structures of the compounds represented by the formulas (3) and (4) mentioned above, depending on the form of the substitution reaction.

The structures depicted at the leading ends of the paths (4) and (8) of the reaction processes A and B mentioned above

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are partial structures of the compounds represented by the formulas (3) and (4) mentioned above.

It has been further found that the secondary production of hydrogen fluoride is repressed to a greater extent by performing the aforementioned reactions of hydrolysis and decarboxylation as divided in at least two steps using different conditions instead of completing them in one step. Specifically, in the multiple stages which are divided into a former step and a latter step, it is made possible to attain more effective prevention of the reaction vessel from corrosion by causing the reaction of 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) to proceed till the conversion ratio exceeds about 40 mol % and performing this reaction under such conditions that the product thereof has 4-amino-2,3,5,6-tetrafluorobenzamide (AFBAm) as a main component thereof and consequently enabling the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) to exceed 40 mol %, preferably 60 mol %, and more preferably 80 mol % while repressing the formation of 2,3,5,6-tetrafluoroaniline (F4NH) in the former step (former step reactions) and completing the hydrolysis and the decarboxylation in the latter step or thereafter.

This more effective prevention of the corrosion may be logically explained by a postulate that though the conversion ratio of 2-amino-3,4,5,6-tetrafluorobenzonitrile (o-AFBN) reaches nearly the same level, the chance of contact of o-AFBN with the target product, 2,3,5,6-tetrafluoroaniline (F4NH), is allayed or the chance of contact of the o-AFBN with the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile (AFBN) is allayed, with the result that the formation of the compound represented by the formula (3) or the formula (4) mentioned above is repressed, and at the same time that the formation of hydrogen fluoride is repressed. Incidentally, the compound represented by the formula (3) or the formula (4) mentioned above is merely intended as an example for illustrating the relation between the presence of impurities and the occurrence of corrosion. This invention is not limited to the presence of this compound and to the repression of the formation thereof. This invention will be described in detail below.

The aromatic cyano compound represented by the general formula (1) which is used in this invention is such that in the general formula (1), the symbol Z denotes a nitrogen-containing group represented by the formula $\text{—N(R}^1\text{)}(\text{R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms). As concrete examples of the nitrogen-containing group, amino group, monomethyl amino group, dimethyl amino group, monoethyl amino group, diethyl amino group, monopropyl amino group, and dipropyl amino group may be cited. Among them, the amino group proves particularly suitable. The symbol Y denotes a cyano group, nitro group, or carboxyl group, the cyano group being preferable. The halogen atom denoted by the symbol X is a fluorine atom, chlorine atom, or bromine atom, the fluorine atom being preferable. In the occurrence of a plurality of X's, the atoms denoted thereby may be identical or not identical with one another.

As concrete examples of the aromatic cyano compound represented by the general formula (1), 4-amino-2,3,5,6-tetrahalogenobenzonitrile, 4-monomethylamino-2,3,5,6-tetrahalogenobenzonitrile, 4-dimethylamino-2,3,5,6-tetrahalogenobenzonitrile, 4-amino-3,5,6-trihalogenophthalonitrile, 4-monomethylamino-3,5,6-trihalogenophthalonitrile, and 4-dimethylamino-3,5,6-trihalogenophthalonitrile may be cited. Among them,

1-amino-2,3,5,6-tetrahalogenobenzonitrile is used particularly advantageously. The halogen atoms considered herein may be individually identical or not identical with one another and may be each a fluorine atom, chlorine atom, or bromine atom. In all the possible species of 1-amino-2,3,5,6-tetrahalogenobenzonitrile, 1-amino-2,3,5,6-tetrafluorobenzonitrile having fluorine atoms as the halogen atoms is used particularly advantageously.

When the aromatic cyano compound mentioned above is hydrolyzed and decarboxylated in this invention, the reaction thereof is carried out in the presence of an acidic substance to produce the aromatic compound represented by the general formula (2).

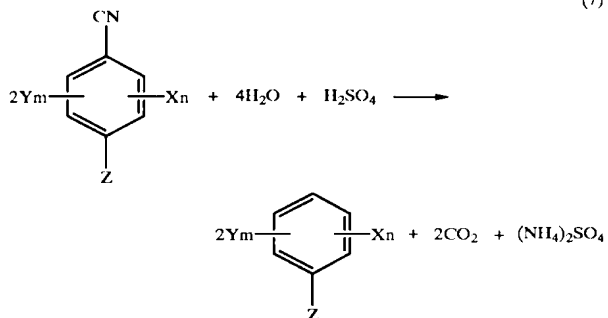
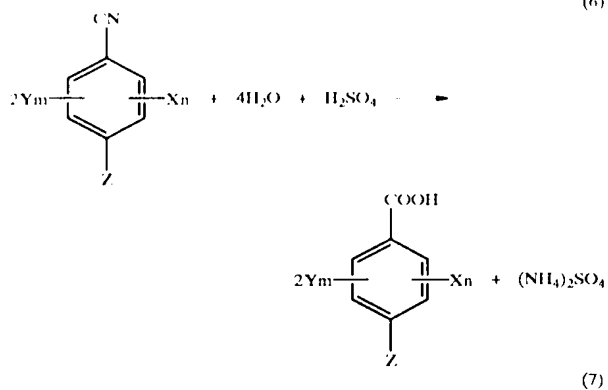
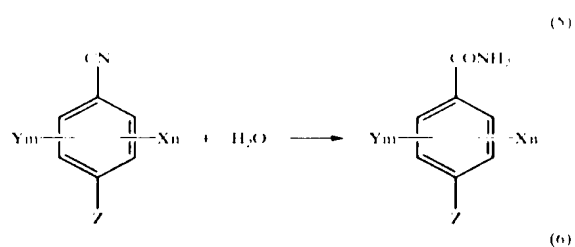
The acidic substance to be used in this reaction does not need to be particularly discriminated, but is only required to be capable of hydrolyzing and decarboxylating the aromatic cyano compound represented by the general formula (1) and consequently forming the aromatic compound represented by the general formula (2). As typical examples of the acidic substance, inorganic acids such as sulfuric acid, hydrochloric acid, and nitric acid and organic acids such as acetic acid, propionic acid, and butyric acid may be cited. Among them, sulfuric acid is used particularly advantageously. The reason for this preference of sulfuric acid is that the reactivity with fluorine atoms is lowered and the reactions of the step (1) and the step (5) are enabled to proceed faster than the reactions of the step (4) and the step (8) because the amino group of the aromatic cyano compound forms a sulfate.

As the reaction vessel in the method of production according to this invention, the reaction vessel which is made of iron or stainless steel and is popularly adopted may be used. When this reaction vessel is liable to be corroded by the acidic substance or by a secondary product which occurs in the process of the reaction as when sulfuric acid is used, for example, the use of a reaction vessel made of glass or lined with glass is commendable. Otherwise, a reaction vessel which is coated with such a corrosion-resistant material as fluorocarbon resin may be used. In consideration of such factors as cost, it is common to use a reaction vessel which is made of glass or lined with glass.

The acidic substance is used together with water of an amount enough for the advance of the reactions of hydrolysis and decarboxylation of the raw material aromatic cyano compound. The acidic substance so used is preferred to have a high concentration. The reason for the high concentration of the acidic substance is that even when the raw material to be used has low purity and contains impurities, the target product, 2,3,5,6-tetrahalogenoaniline, can be obtained in a high yield without inducing corrosion of the reaction vessel. The high yield of this product may be logically explained by a supposition that when the reactions of hydrolysis and decarboxylation are carried out by using an aqueous sulfuric acid solution of a comparatively high concentration, for example, the cyano group of the impurity, 2-amino-3,4,5,6-tetrahalogenobenzonitrile, is hydrolyzed fast, the electron attracting property of the cyano group is degraded, and the readily displaceable fluorine atom at the para position relative to the cyano group is rendered less susceptible of the reaction of substitution. Further, it is inferred that since the amino group which incites fluorine atoms to undergo a reaction of nucleophilic substitution forms a salt with sulfuric acid, the reactivity of nucleophilic substitution manifested on the fluorine atoms is degraded. Though this invention is not restrained by the foregoing theoretical consideration, the acidic substance is preferred to be used in the form of an aqueous solution. The concentration of the acidic substance in this aqueous solution is properly in the

range of 80 to 98 weight %, preferably in the range of 83 to 96 weight %, and more preferably in the range of 84 to 94 weight %. The reason for this range is that the product acquires the characteristic properties mentioned above when the concentration is in this range. Incidentally, the concentration of the acidic substance mentioned here means the concentration of the acidic substance which exists during the charging of the reaction vessel with the raw material or during the course of the reaction.

When an aqueous solution of sulfuric acid is used as the acidic substance, for example, since the reactions represented by the following chemical formulas (5), (6), and (7) proceed as shown by the schema in consequence of the addition of the raw material compound to the reaction mixture, the water and the sulfuric acid forming the aqueous solution are consumed proportionately and the concentration of the acidic substance in the aqueous solution is changed accordingly. Thus, the concentration of sulfuric acid which is found by determining the ratio of formation of the product in the reaction solution as by means of liquid chromatography, for example, and computing the amount of water and the amount of sulfuric acid remaining in the reaction solution based on the following chemical formulas is the concentration of the acidic substance contemplated by this invention.



This invention is characterized by performing the reactions of hydrolysis and decarboxylation in multiple stages. In the method of this invention for the production of the

aromatic compound, the reaction for hydrolyzing the CN group of the aromatic cyano compound represented by the general formula (1) into the COOH group and the reaction for decarboxylating the COOH group into the hydrogen atom proceed parallelly. The term "reactions of hydrolysis and decarboxylation" as used in this invention, therefore, is meant to express the hydrolysis and the decarboxylation collectively as a series of reactions. The expression that "the hydrolysis and the decarboxylation are performed in multiple steps," therefore, means to divide the aforementioned series of reactions into a former step in which the reactions proceed till a certain state and a latter step in which the target product is obtained at the end of the reactions. Properly, the reaction of hydrolysis is performed to a prescribed extent and thereafter, with the product of the hydrolysis left unseparated, the reaction of decarboxylation is continued under different conditions till the reactions are completed. When the reactions of hydrolysis and decarboxylation are performed in multiple stages as described above, the target product can be obtained in a high yield because the former step which is intended to effect partial hydrolysis serves to lower the reactivity of the substituent located at the para position or the ortho position with the cyano group and repress the formation of a secondary product and, particularly even when the raw material aromatic cyano compound contains impurities having halogen atoms as the component, Z, and prevent the reaction vessel from being corroded owing to the secondary production of hydrogen halogenide, and the latter step serves to complete the reactions.

The reactions of hydrolysis and decarboxylation in this invention are initiated by adding the raw material aromatic cyano compound to the reaction vessel. The reaction vessel may be charged preparatorily with the aqueous solution of the acidic substance as described above. The raw material may be added to the reaction vessel all at once, sequentially, or continuously. For this invention, the sequential addition of the raw material proves favorable in respect that it enables the selectivity of the reaction to be heightened and prevents the reaction vessel from being corroded. When the raw material is in a solid state, it may be fed to the reaction vessel in its unmodified form, or after being pulverized into a powdery state, or after being heated to a temperature higher than the melting point and consequently reduced to a molten state.

The temperature of the reactions of hydrolysis and decarboxylation is generally in the range of 50 to 180° C., preferably in the range of 60 to 160° C., and more preferably in the range of 70 to 140° C. under normal pressure. The pressure may be normal pressure, reduced pressure, or increased pressure, whichever fits the occasion best. Generally, the reactions are carried out under normal pressure or reduced pressure.

In this invention, the former step reactions are so performed that the conversion ratio of the raw material aromatic cyano compound reaches a level of not lower than 40 mol %, preferably not lower than 60 mol %, and more preferably not lower than 80 mol % and they are terminated under such conditions that the amount of the final product (the target product, which is the aromatic compound represented by the general formula (2)) to be formed is not more than 80 mol %, preferably not more than 70 mol %, and more preferably not more than 60 mol %, based on the raw material aromatic cyano compound. In other words, the reaction mixture obtained at the end of such former step reactions are enabled to contain an amide compound as the main component. Then, for the latter step reactions, the reaction conditions are so selected that the reaction of carboxylation and decarboxy-

lation of the amide group or the reaction of decarboxylation of the carboxyl group proceeds efficiently until completion.

The reaction conditions which fulfill the conversion ratio and the amount of formation mentioned above, specifically with respect to the reaction temperature and the concentration of the acidic substance in the aqueous solution may be properly selected from the aforementioned ranges of reaction temperature and concentration of aqueous solution with respect to the contents of the reactions mentioned above. As the conditions of the former step reactions, the concentration of the acidic substance in the aqueous solution, more specifically the concentration of sulfuric acid, to be used is properly in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and particularly in the range of 84 to 94 weight %. As the conditions of the latter step reactions, the concentration of the acidic substance is lowered by adding water to the reaction system to a level in the range of 50 to 95 weight %, preferably in the range of 60 to 90 weight %, and particularly in the range of 65 to 85 weight %. Specifically, the concentration of the acidic substance in the latter step is lowered from the concentration of the acidic substance in the former step by a margin in the range of 5 to 50 weight %, preferably in the range of 10 to 30 weight %. Otherwise, the reaction temperature is elevated from that of the former step by a margin in the range of 5 to 50° C., and preferably in the range of 10 to 40° C. As a result, the formation of the aromatic compound as the final product is repressed and the reaction of the raw material aromatic cyano compound is promoted by the former step reactions and the reaction of carboxylation and decarboxylation or the reaction of decarboxylation is expedited and completed fast by the latter step reactions. In this respect, the method for the production of the aromatic compound is characterized by performing the reactions while varying the conditions of lowering the concentration of the acidic substance and/or raising the reaction temperature in the former step and the latter step in the multiple steps.

This invention is particularly effective when the raw material to be used contains as an impurity a compound having the nitrogen-containing group present in the aromatic cyano compound located at a different position. To be specific, the possibility of the aforementioned reactions by-producing the hydrogen halogenide is high when 4-amino-2,3,5,6-tetrahalogenobenzonitrile is used as the aromatic cyano compound and it contains as an impurity 2-amino-3,4,5,6-tetrahalogenobenzonitrile (o-AFBN), for example. By this invention, it is made possible to repress the secondary production of the hydrogen halogenide and preclude the occurrence of such problems as corrosion.

When 4-amino-2,3,5,6-tetrafluorobenzonitrile is used, for example, as the raw material, the conventional method necessitates a process for preparatorily purifying this raw material by such a treatment as recrystallization. By this invention, however, it is made possible to obtain the target product in a high yield without requiring such a process of purification. The 4-amino-2,3,5,6-tetrafluorobenzonitrile can be produced, for example, by causing this compound to form a diphasic state by the use of water and an organic solvent capable of forming a dibasic state with water and allowing the pentafluorobenzonitrile in the dibasic state to react with ammonia. The reaction temperature in this case is generally not higher than 70° C. As typical examples of the organic solvent, aliphatic acid esters, ketones, and benzonitriles may be cited. Thus, this invention enables the target product, i.e. the aromatic compound represented by the general formula (2), efficiently in a high yield even when the 4-amino-2,3,5,6-tetrafluorobenzonitrile containing the

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impurity formed by such a method is used in its unmodified form. Incidentally, the 4-amino-2,3,5,6-tetrafluorobenzonitrile formed by the method mentioned above may be used after being refined as by recrystallization to a higher degree of purity. In any event, this invention does not need to impose any limitation on the purity of 4-amino-2,3,5,6-tetrafluorobenzonitrile. Generally, so long as the purity is in the range of 80 to 100 weight %, preferably in the range of 90 to 99 weight %, the target product can be obtained efficiently without entailing such problems as the corrosion of the reaction vessel. The method of this invention is effective when the 4-amino-2,3,5,6-tetrafluorobenzonitrile which contains such an impurity as 2-amino-3,4,5,6-tetrafluorobenzonitrile and shows a purity of not higher than 97%, or not higher than 95% is used in the reaction.

Now, this invention will be described below with reference to the operation of producing 2,3,5,6-tetrafluoroaniline by using 4-amino-2,3,5,6-tetrafluorobenzonitrile as the raw material and sulfuric acid as the acidic substance.

In this invention, the reactions of hydrolysis and decarboxylation are generally fulfilled by feeding the aqueous solution of sulfuric acid to the reaction vessel made of glass or lined with glass and adding thereto 4-amino-2,3,5,6-tetrafluorobenzonitrile as the raw material. The raw material may be added to the reaction vessel all at once, or sequentially, or continuously. The sequential addition of the raw material, however, proves favorable because it gives high selectivity of the reaction and prevents the reaction vessel from corrosion. When the raw material is added sequentially, the speed of this addition may be properly selected. Favorably, this addition is made at a rate in the range of 0.1 to 20 weight parts and preferably in the range of 1 to 10 weight parts per hour, based on 100 weight parts of the aqueous solution of sulfuric acid. The addition of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile, is preferred to be completed prior to the termination of the former step reactions.

The sulfuric acid is used in an amount enough for permitting smooth advance of the reactions of hydrolysis and decarboxylation of 4-amino-2,3,5,6-tetrafluorobenzonitrile together with water. Generally, it is used as an aqueous sulfuric acid solution. The concentration of sulfuric acid in the aqueous sulfuric acid solution is in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight %.

The temperature of the reactions of hydrolysis and decarboxylation under normal pressure is generally in the range of 50 to 180° C., preferably in the range of 60 to 160° C., and more preferably in the range of 70 to 140° C.

The former step reactions are performed till the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile reaches a level of not lower than 40 mol %, preferably not lower than 60 mol %, and more preferably not lower than 80 mol % and are terminated when the amount of 2,3,5,6-tetrafluoroaniline formed in the reaction solution is not more than 80 mol %, preferably not more than 70 mol %, and more preferably not more than 60 mol %, based on the amount of 4-amino-2,3,5,6-tetrafluorobenzonitrile as the raw material.

Subsequently, the latter step of the process comprises adding water to the reaction mixture formed after completion of the former step reactions thereby diluting the initially charged aqueous sulfuric acid solution to a concentration in the range of 50 to 95 weight %, preferably in the range of 60 to 90 weight %, and more preferably in the range of 65 to 85 weight % and continuing the reactions on the resultant diluted reaction mixture.

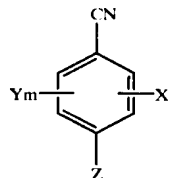
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Another method of this invention comprises performing the former step reactions at a comparatively low temperature, specifically a temperature in the range of 50 to 170° C., preferably in the range of 60 to 150° C., and more preferably in the range of 70 to 130° C., and performing the latter step reactions at a higher temperature than for the former step reactions, specifically at a temperature in the range of 60 to 180° C., preferably in the range of 70 to 160° C., and more preferably in the range of 80 to 140° C.

The former step reactions are performed with the concentration of the acidic acid, specifically the concentration of sulfuric acid, fixed at a level in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight % and the reaction temperature at a level in the range of 50 to 170° C., preferably in the range of 60 to 150° C., and more preferably in the range of 70 to 130° C. Subsequently the latter step reactions are performed with the concentration of the acidic substance, specifically the concentration of sulfuric acid, initially fed to the reaction vessel lowered by dilution to a level in the range of 50 to 95 weight %, preferably 60 to 90 weight % more preferably in the range of 65 to 85 weight % with a margin in the range of 5 to 50 weight %, preferably in the range of 10 to 30 weight % and the reaction temperature increased to a level in the range of 55 to 180° C., preferably in the range of 70 to 160° C., and more preferably in the range of 80 to 140° C. with a margin in the range of 5 to 50° C., preferably in the range of 10 to 40° C. As the standards for the completion of the former step reactions, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile is not less than 40 mol % and the amount of formation of 2,3,5,6-tetrafluoroaniline is not more than 80 mol %. The 2,3,5,6-tetrafluoroaniline which is consequently obtained can be recovered and turned into a finished product by following the ordinary procedure.

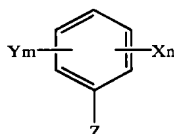
The second aspect of this invention is the method for the production of an aromatic compound, characterized by forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently recovering the obtained aromatic compound from the reaction solution by azeotropic distillation with water.

(1)



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by —N(R¹)(R²) (wherein R¹ and R² are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 ≤ m+n ≤ 4.)

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(wherein the symbols have the same meanings as in the general formula (1).)

The compound mentioned above is the same as that of the first aspect of this invention.

The second invention described above is characterized by hydrolyzing and decarboxylating the aromatic cyano compound in the presence of an aqueous medium. When the reactions are performed by using as the aqueous medium, the aqueous solution of an acidic substance such as, for example, sulfuric acid, and fixing the concentration of the acidic substance at a level of 80 weight %, the reactivity with fluorine atoms is degraded and the secondary production of hydrogen fluoride is repressed because the reactions of the step (1) and the step (5) proceed much faster than the reactions of the step (4) and the step (8) and the amino group forms a sulfate as described already in the first invention. When the aqueous medium is an alkaline substance, the target compound can be produced even with the alkaline substance. Further, by azeotropically distilling the reaction solution, the target compound can be produced in a high yield without inducing corrosion of the reaction vessel. Thus, the second aspect of this invention is enabled to produce the aromatic compound in a high yield by recovering the target compound formed in the presence of the aqueous medium by azeotropic distillation with water from the reaction solution, no matter whether the hydrolysis and the decarboxylation are effected in one step or the reactions of hydrolysis decarboxylation are effected in multiple steps, i.e. in at least not less than two steps using different reaction conditions.

The aqueous medium for use in this invention is only required to be capable of dissolving the raw material compound and may be an acidic substance or an alkaline substance. It may contain other compounds, alcohols, and aprotic polar solvents, for example.

As the aqueous medium, the acidic substance used for the first aspect of this invention may be used. As typical examples of the aqueous medium, inorganic acids such as sulfuric acid, hydrochloric acid, and nitric acid and organic acids such as acetic acid, propionic acid, and butyric acid may be cited. Among them, sulfuric acid is used particularly advantageously. First, when the aqueous medium contain an acidic substance, the concentration of the acidic substance in the aqueous medium is in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %. The expression "concentration of the acidic substance contained in the aqueous medium" as used herein means the concentration of the acidic substance existing during the charging of the reaction vessel or during the process of the reaction.

Now, this invention will be described below with reference to one example thereof, i.e. the procedure wherein the aqueous medium is an acidic substance, sulfuric acid is used as the acidic substance, and 4-amino-2,3,5,6-tetrafluorobenzonitrile is used as the raw material compound.

This invention can be extensively applied to reaction solutions which contain aromatic compounds of the general formula (2) formed by hydrolyzing and decarboxylating aromatic cyano compounds represented by the general for-

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mula (1) under the condition having sulfuric acid containing at a concentration in the range of 80 to 98 weight %.

When the reactions use sulfuric acid, the reaction vessel in popular use which is made of glass or lined with glass is adopted. A reaction vessel which is coated as with a fluorocarbon resin may be used instead.

The reaction vessel is preparatorily charged with an aqueous sulfuric acid solution containing sulfuric acid at a concentration in the range of 80 to 98 weight %, preferably in the range of 82 to 96 weight %, and more preferably in the range of 84 to 94 weight %. If the concentration of the aqueous sulfuric acid solution to be used falls short of 80 weight %, the shortage will be at a disadvantage in not only degrading the reaction speed but also inducing corrosion of the reaction vessel. If it exceeds 98 weight %, the excess will be at a disadvantage in decreasing the speed of the formation of 4-amino-2,3,5,6-tetrafluorobenzoic acid which is the precursor of 2,3,5,6-tetrafluoroaniline and consequently lowering the speed of the formation of 2,3,5,6-tetrafluoroaniline.

The reaction temperature is in the range of 50 to 180° C., preferably in the range of 60 to 170° C., and more preferably in the range of 70 to 160° C. If this temperature falls short of 50° C., the shortage will be at a disadvantage in lowering the speed of the reaction. Conversely, if the temperature exceeds 180° C., the excess will be at a disadvantage in lowering the selectivity of the reaction.

The reactions of hydrolysis and decarboxylation are generally carried out by charging the reaction vessel with the aqueous sulfuric acid solution and adding thereto the raw material, i.e. 4-amino-2,3,5,6-tetrafluorobenzonitrile. The addition of the raw material may be made all at once or sequentially. The sequential addition of the raw material is favorable because the reactions enjoy high selectivity and the reaction vessel is prevented from corrosion. When the raw material is sequentially added, the speed of the addition may be properly selected. Favorably, this addition is made at a rate in the range of 0.1 to 20 weight parts, preferably in the range of 1 to 10 weight parts, per hour based on 100 weight parts of the charged aqueous sulfuric acid solution.

The expression "forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently" as used herein means that the molar ratio of the aromatic compound formed in the reaction vessel is not less than 85 mol %, preferably 90 mol %, and particularly preferably 95 mol %, based on the initial amount of the aromatic cyano compound represented by the formula (1). If the molar ratio falls short of 85 mol %, the shortage will be at a disadvantage in inducing the reaction vessel made of glass to sustain corrosion. After the aromatic compound represented by the general formula (2) has been formed, the product can be distilled with water azeotropically.

Favorably, the concentration of the acid substance in the aqueous medium prior to the azeotropic distillation is adjusted, as occasion demands, to a level falling short of 58 weight %, further to not more than 50 weight %, and further to not more than 40 weight %. Specifically, the adjustment of the concentration to the range mentioned above is favorably attained by using water.

When the aqueous medium is an alkaline substance, it suffices to have the concentration of the alkaline substance in the aqueous medium adjusted to a level within the range mentioned above. The adjustment of the concentration to the range mentioned above may be attained by incorporating into the aqueous medium a dilute acidic substance or alkaline substance in an amount enough for the adjustment.

Then, the azeotropic distillation which characterizes the present invention will be explained below.

From the reaction solution which is obtained as described above, the formed 2,3,5,6-tetrafluoroaniline is recovered by azeotropic distillation with water. In this case, the azeotropic distillation may be carried out after the reaction solution obtained in the presence of the aqueous medium has been mixed with water. The mixing of the reaction solution with water may be attained by adding water to the reaction solution, adding the reaction solution to a separate reaction vessel which has been charged in advance with water, or adding part of water to the reaction solution and feeding the resultant mixture to a separate reaction vessel. Generally, a method which comprises returning the temperature of the water fed to a separate reaction vessel at a prescribed level and thereafter adding the reaction solution dropwise into the water is favorably adopted. As the aqueous medium, water or a mixture of water with an organic solvent miscible with water may be used. The use of water as the aqueous medium proves economical and advantageous in the sense that the azeotropic distillation can be performed under a favorable condition.

The amount of the water to be used for the mixing mentioned above is in the range of 0.1 to 10 weight parts, preferably in the range of 0.2 to 5 weight parts, and more preferably in the range of 0.3 to 3 weight parts, based on one weight part of the reaction solution. Generally, the water is preparatorily placed in a necessary amount collectively in a separate reaction vessel. After the azeotropic distillation has been started, the distillate is divided into water and 2,3,5,6-tetrafluoroaniline and the water expelled by this distillation is circulated to the reaction solution.

The azeotropic distillation is carried out with the temperature of the distillate in the reaction vessel (the so-called azeotropic temperature) fixed at a level in the range of 80 to 150° C., preferably in the range of 90 to 130° C. Though the pressure proper for this distillation may be either normal pressure or reduced pressure, the normal pressure proves more favorable.

The azeotropic distillation performed as described above can be likewise applied to the reaction solution which is obtained in and after the latter step of the process of the first aspect of this invention.

Now, this invention will be described below with reference to one example thereof, i.e. the procedure wherein the aqueous medium contains an alkaline substance, 4-amino-2,3,5,6-tetrafluorobenzonitrile is used as the aromatic cyano compound represented by the general formula (1), and 2,3,5,6-tetrafluoroaniline is produced as the aromatic compound represented by the general formula (2).

This invention concerns a process which comprises a step of hydrolyzing 4-amino-2,3,5,6-tetrafluorobenzonitrile under a condition containing an alkaline substance as the aqueous medium thereby obtaining 4-amino-2,3,5,6-tetrafluorobenzoic acid and/or a salt thereof (such as, for example, a sodium salt when the alkaline substance is sodium hydroxide) (hereinafter, indicated as 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt)), a step of decarboxylating the compound by the reaction of decarboxylation, and finally a step of recovering the formed 2,3,5,6-tetrafluoroaniline by azeotropic distillation with water.

The alkaline substance to be used in the step for hydrolysis mentioned above does not need to be particularly discriminated but is only required to be capable of hydrolyzing 4-amino-2,3,5,6-tetrafluorobenzonitrile and consequently forming 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt). Alkali metal salts, alkaline earth metal salts, and amines, for

example, may be used as the alkaline substance. As concrete examples of the alkali metal salts, sodium hydroxide, potassium hydroxide, sodium carbonate, potassium carbonate, sodium hydrogen carbonate, and potassium hydrogen carbonate may be cited. As concrete examples of the alkaline earth metal salts, calcium hydroxide and calcium carbonate may be cited. The use of sodium hydroxide, among them, proves particularly advantageous by reason of economy. The combined use of sodium hydroxide and calcium hydroxide proves favorable from the viewpoint of preventing the reaction vessel from corrosion. As concrete examples of the amines, alkyl amines such as dimethyl amine, trimethyl amine, ethyl amine, diethyl amine, triethyl amine, butyl amine, dibutyl amine, and tributyl amine and pyridine and quinoline may be cited. These alkaline substances may be used either singly or in the form of a combination of two or more members.

The amount of the alkaline substance to be used is in the range of 0.1 to 20 weight parts, preferably in the range of 0.3 to 10 weight parts, and more preferably in the range of 0.5 to 5 weight parts, based on one weight part of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile. If the amount of the alkaline substance to be used is excessive, the excess will be at a disadvantage in inducing the raw material to undergo a reaction for halogen substitution and lowering the selectivity of the reactions. If the amount is unduly small, the shortage will be at a disadvantage in preventing the reactions from proceeding smoothly.

The reaction of hydrolysis is properly carried out in an aqueous medium. As the aqueous medium, water may be used alone or in combination with a solvent miscible with water. As the solvent of this nature, alcohols, aprotic polar solvents, ketones, and esters can be used. As concrete examples of the alcohols, methanol, ethanol, n-propanol, isopropanol, ethylene glycol, and propylene glycol may be cited. As concrete examples of ketones, acetone, methyl-ethyl ketone, and methyl isobutyl ketone may be cited. As concrete examples of esters, acetic esters such as ethyl acetate, propyl acetate, and butyl acetate may be cited. As concrete examples of aprotic polar solvents, dimethyl formamide (DMF), dimethyl sulfoxide (DMSO), and n-methyl pyrrolidone may be cited.

The amount of the aqueous medium to be used is in the range of 1 to 50 weight parts, preferably in the range of 2 to 30 weight parts, and more preferably in the range of 3 to 10 weight parts, based on one weight part of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile. If this amount is unduly large, the excess will be at a disadvantage in degrading the productivity of the target compound. If the amount is unduly small, the shortage will be at a disadvantage in preventing the reactions from advancing smoothly.

The reaction temperature is in the range of 20 to 200° C., preferably in the range of 30 to 150° C., and more preferably in the range of 40 to 100° C. If the reaction temperature is excessively high, the excess will be at a disadvantage in increasing secondary products due to the reaction of halogen substitution of the raw material and consequently lowering the selectivity of the target compound. Conversely, if the reaction temperature is excessively low, the shortage will be at a disadvantage in preventing the reactions from advancing at an economically sufficient speed.

The present process, because of the use of an alkaline substance, conspicuously allays the corrosion of the reaction vessel as compared with the conventional process which uses an acidic substance.

Now, the step of decarboxylation will be explained below. This is the step of performing the reaction of decarboxyla-

tion of the 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt) formed by the reaction of hydrolysis.

The reaction of decarboxylation may be attained by directly heating the aqueous medium containing the 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt) formed by the reaction of hydrolysis. It may be otherwise fulfilled by adding for the reactions an alkaline substance different from the alkaline substance used at the step of hydrolysis. As concrete examples of the alkaline substance proper for the addition, those alkaline substances enumerated above may be cited. Among other alkaline substances mentioned above, the alkaline earth metal salts prove advantageous because they allow the reactions to proceed more smoothly and prevent the reaction vessel from being corroded with the fluorine ions formed by the secondary reaction involved in the step of decarboxylation. The amount of the alkaline earth metal salt to be used is in the range of 0.01 to 2 weight parts, preferably in the range of 0.02 to 1 weight part, and more preferably in the range of 0.03 to 0.5 weight part, based on one weight part of the 4-amino-2,3,5,6-tetrafluorobenzoic acid (salt). If the amount so used is unduly large, the excess will be at a disadvantage in increasing the secondary products due to the reaction of halogen substitution of the raw material and consequently lowering the selectivity of the target compound. Conversely, if this amount is unduly small, the shortage will be at a disadvantage in precluding fulfillment of the effect mentioned above.

The decarboxylation may be effected after the alkaline substance existing in the aqueous medium has been partially or completely neutralized by the addition of an acidic substance to the aqueous medium.

The acidic substance mentioned above may be either an inorganic acid or an organic acid. As concrete examples of the inorganic acid, hydrochloric acid, sulfuric acid, and nitric acid may be cited. As concrete examples of the organic acid, formic acid, acetic acid, propionic acid, and butyric acid may be cited. By reason of economy, sulfuric acid is used particularly favorably among them. The amount of the acidic substance to be used is in the range of 0.1 to 2 equivalents, preferably in the range of 0.3 to 1.5 equivalents, and more preferably in the range of 0.5 to 1 equivalent, based on the weight of the alkaline substance. If this amount is unduly small, the shortage will be at a disadvantage in preventing the target compound from being obtained at a sufficiently high speed of reaction. Conversely, if the amount is unduly large, the excess will be at a disadvantage in compelling the reaction of decarboxylation to proceed under an acidic condition, increasing the secondary products due to the reaction of halogen substitution of the raw material, and consequently inducing corrosion of the reaction vessel due to the generation of hydrogen fluoride.

The reaction of decarboxylation may be performed under either normal pressure or increased pressure. Favorably, it is carried out under increased pressure such as, for example, a pressure in the approximate range of 0.1 to 5 MPa because the reactions proceed more smoothly under the increased pressure. When the reactions are performed under the increased pressure, they may be effected by using a pressure-resistant reaction vessel and keeping a closed system therein by accumulating a gas in the reaction vessel. The reactions may be otherwise carried out by partially extracting from the reaction vessel the gas having as its main component the carbon dioxide gas generated by the reactions thereby keeping the pressure in the reaction vessel at a fixed level.

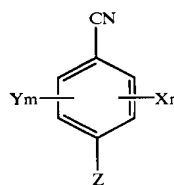
The reaction temperature is in the range of 30 to 200° C., preferably in the range of 50 to 180° C., and more preferably in the range of 70 to 160° C. If the reaction temperature is

unduly high, the excess will be at a disadvantage in increasing the secondary products due to the reaction of halogen substitution of the raw material and consequently entailing such problems as corrosion of the reaction vessel due to the generation of hydrogen fluoride. Conversely, if the reaction temperature is unduly low, the shortage will be at a disadvantage in preventing the reactions from proceeding smoothly.

The step of hydrolysis and the step of decarboxylation mentioned above may be performed in one and the same reaction vessel or indifferent reaction vessel. As the reaction vessel, the reaction vessel in common use which is made of carbon steel or stainless steel may be used.

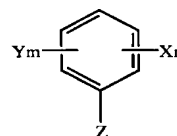
The molar ratio of the aromatic compound to be formed in the reaction vessel engaging in azeotropic distillation, similarly to the reactions using an aqueous solution as an acidic substance, means that the molar ratio of the aromatic compound of the general formula (2) to be formed reaches a level of not less than 85 mol %, preferably 90 mol %, and more preferably 95 mol %, based on the initial amount of the aromatic cyano compound represented by the formula (1). The step of azeotropic distillation is the same as when the acidic substance is used.

The third aspect of this invention is in the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the hydrolysis and decarboxylation in multiple steps and effecting the recovery of the formed aromatic compound from the reaction solution by azeotropic distillation with water.



(1)

(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{—N(R}^1\text{)(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$.)



(2)

(wherein the symbols have the same meanings as in the general formula (1).)

The third invention is directed to a process which comprises hydrolyzing and decarboxylating the aromatic cyano compound represented by the general formula (1) in multiple steps including a former step and a latter step using different reaction conditions in the presence of the acidic

substance thereby producing the aromatic compound represented by the general formula (2) and subsequently recovering the formed aromatic compound from the reaction solution by azeotropic distillation with water. Since the reactions are performed in at least two steps by using the acidic substance, the secondary production of such a corrosive substance as hydrofluoric acid can be repressed. Further, since the target compound is recovered by azeotropy, it is made possible to prevent the reaction vessel from being corroded during the course of the azeotropy and enable the target compound to be produced in a high yield.

The compounds represented by the general formulas (1) and (2) mentioned above are the same as those of the first aspect of this invention. Further, the "acidic substance" to be used and the conditions for performing "the reactions of hydrolysis and decarboxylation in multiple steps including a former step and a latter step using different reaction conditions" are the same as those which have been covered in the foregoing description of the first aspect of the invention. In the present invention, the molar ratio of the aromatic compound of the formula (2) formed in the reaction vessel is not less than 85 mol %, preferably 90 mol %, and more preferably 95 mol %, based on the initial amount of the aromatic cyano compound represented by the formula (1). If this molar ratio falls short of 85 mol %, the shortage will be at a disadvantage in inducing the reaction vessel of glass used for the reactions of hydrolysis and decarboxylation or in the step of azeotropy to sustain corrosion. The conditions for azeotropically distilling the formed aromatic compound are the same as those which are covered by the foregoing description of the second aspect of the invention.

EXAMINATIONS

Now, this invention will be described more specifically with reference to working examples adduced hereinafter for illustration.

Referential Example 1

Synthesis of 4-amino-2,3,5,6-tetrafluorobenzonitrile

A 500 ml four-neck flask provided with a stirrer, a thermometer, and a cooling tube was charged with 75 g (389 mmols) of pentafluorobenzonitrile, 225 ml of n-propyl acetate, 79.5 g of an aqueous 25% ammonia solution (1.165 mols as ammonia), and 0.375 g of tetrabutyl ammonium bromide. The contents of the reaction vessel were left reacting at 25° C. for one hour and further reacting at 50° C. for five hours. When the reaction solution obtained after completion of the reaction was analyzed by gas chromatography, the conversion ratio of pentafluorobenzonitrile was found to be 100% and the yield of the target component, 4-amino-2,3,5,6-tetrafluorobenzonitrile to be 94%.

The n-propyl acetate layer containing 4-amino-2,3,5,6-tetrafluorobenzonitrile was separated and washed twice with 100 g of an aqueous 10 weight % sodium sulfate solution to remove the ammonium fluoride contained in the layer. Subsequently, the n-propyl acetate layer was heated to expel the n-propyl acetate by distillation and obtain 73.5 g of 4-amino-2,3,5,6-tetrafluorobenzonitrile (purity 94%) (yield 93.6%). The product contained 4.5 g (6%) of 2-amino-3,4,5,6-tetrafluorobenzonitrile as an impurity.

EXAMPLE 1

(Former Step Reactions)

A 200 ml four-neck flask made of glass and provided with a stirrer, a thermometer, and a cooling tube was charged with

120 g of an aqueous 90 weight % sulfuric acid solution and heated till the internal temperature thereof reached 110° C., with the solution kept stirred. Subsequently, 50 g of the solid obtained in Referential Example 1 (having a 4-amino-2,3,5,6-tetrafluorobenzonitrile content of 94%) was fed at a feed rate of 1 g/h to an aqueous 90 weight % sulfuric acid solution kept at 110° C. The concentration of sulfuric acid in the reaction vessel during the former step reactions was in the range of 90 to 94 weight %. After the feeding was completed, the reaction was further continued for two hours. When the reaction solution was sampled and analyzed by liquid chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was 100 mol % and the products formed in the reaction solution were found to be as follows:

- 4-Amino-2,3,5,6-tetrafluorobenzamide 65 mol %
- 4-Amino-2,3,5,6-tetrafluorobenzoic acid 10 mol %
- 2,3,5,6-Tetrafluoroaniline 20 mol %

(Latter Step Reactions)

By adding 22 g of water to the reaction solution mentioned above, the concentration of the aqueous sulfuric acid solution was adjusted to 80 weight % and the reaction was continued for 15 hours. The concentration of sulfuric acid in the reaction vessel during the latter step reactions was 80 weight %. When the reaction solution obtained after completion of the reaction was sampled and analyzed by liquid chromatography, the yield of 2,3,5,6-tetrafluoroaniline was found to be 98 mol %.

(Step of Azeotropy)

A 500 ml four-neck flask made of glass and provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube was charged with 300 ml of water and heated to 100° C., with the water therein as kept stirred, to retain a state of reflux in the reaction vessel.

The reaction solution obtained in the step of hydrolysis and decarboxylation was placed in the dropping funnel, retained at 110° C. by means of an electric heater, and added dropwise into the flask over a period of one hour, and subjected to azeotropic distillation to expel 2,3,5,6-tetrafluoroaniline into the water separating tube.

The upper layer of the distillate collecting in the water separating tube was water and the lower layer thereof was 2,3,5,6-tetrafluoroaniline. The expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours, with the distilled water circulated continuously into the flask.

From the water separating tube, 39.4 g of 2,3,5,6-tetrafluoroaniline was obtained. When this compound was analyzed by gas chromatography, the purity thereof was found to be 99.5%. The total yield in the step of hydrolysis and decarboxylation and the step of azeotropic distillation was found to be 96.0%. When the inner walls of the reaction vessels used for the hydrolysis and decarboxylation and for the azeotropic distillation were visually inspected, no discernible sign of corrosion was detected.

(Determination of Annual Ratio of Corrosion)

The reaction vessels used in the reactions mentioned above were measured for annual ratio of corrosion. The reactions of hydrolysis and decarboxylation were carried out by following the procedure described above while using a 500 ml separable flask made of stainless steel lined with a fluorocarbon resin in place of a flask made of glass, having a glass test piece (pestle type, made by NGK Insulators Ltd., and sold under the product code of "GL-400") immersed near the interface, and tripling the amounts of the aqueous sulfuric acid solution and the solid, and the speed of addition of the solid. This reaction was performed up to two repeti-

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tions. When the test piece which had undergone the reaction three times was taken out and tested for annual ratio of corrosion in accordance with the following formula. The ratio was found to be 0.02 mm/year.

$$\text{Annual ratio of corrosion (mm/year)} = \{[(W_0 - W_1)/D]/S\} \times \{[24(\text{hr/day}) \times 365(\text{days/year})]/T\}$$

wherein

W_0 : weight of test piece before the test (mg)

W_1 : weight of test piece after the test (mg)

D: specific gravity of test piece (mg/mm³)

S: surface area of test piece (mm²)

T: duration of test (hr)

EXAMPLE 2

(Reactions of Hydrolysis and Decarboxylation)

A 200 ml four-neck flask made of glass and provided with a stirrer, a thermometer, and a cooling tube was charged with 100 g of an aqueous 90% sulfuric acid solution and heated till the internal temperature thereof reached 100° C., with the solution as kept stirred. Then, 50 g of the solid (having a 4-amino-2,3,5,6-tetrafluorobenzonitrile content of 94%) obtained in Referential Example 1 was fed at a feed rate of 4 g/h to an aqueous 90% sulfuric acid solution, with the solution as kept stirred. After the supply was completed, the reaction was continued further for two hours. When the reaction solution was sampled and analyzed by liquid chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was found to be 98 mol % and the products formed in the reaction solution were found to be as follows.

4-Amino-2,3,5,6-tetrafluorobenzamide 55 mol %

4-Amino-2,3,5,6-tetrafluorobenzoic acid 10 mol %

2,3,5,6-Tetrafluoroaniline 8 mol %

The concentration of the aqueous sulfuric acid solution was adjusted to 80% by adding 19 g of water to the reaction solution and also heated to 120° C. The ensuing reaction was continued for 15 hours. When the reaction solution obtained after completion of the reaction was sampled and analyzed by liquid chromatography, the yield of 2,3,5,6-tetrafluoroaniline was found to be 98%.

(Step of Azeotropy)

A 500 ml four-neck flask made of glass and provided with a stirrer, a thermometer, a dropping funnel, and a water

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The reaction solution obtained in the step of hydrolysis and decarboxylation was placed in the dropping funnel, retained at 110° C. by means of an electric heater, and added drop wise into the flask over a period of one hour, and subjected to azeotropic distillation to expel 2,3,5,6-tetrafluoroaniline into the water separating tube.

The upper layer of the distillate collecting in the water separating tube was water and the lower layer thereof was 2,3,5,6-tetrafluoroaniline. The expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours, with the distilled water circulated continuously into the flask.

From the water separating tube, 39.7 g of 2,3,5,6-tetrafluoroaniline was obtained. When this compound was analyzed by gas chromatography, the purity thereof was found to be 99.8%.

The total yield in the step of hydrolysis and decarboxylation and the step of azeotropic distillation was found to be 97.1%. When the inner walls of the reaction vessels used for the hydrolysis and decarboxylation and for the azeotropic distillation was visually inspected, no discernible sign of corrosion was detected.

(Determination of Annual Ratio of Corrosion)

When the reaction vessels used in the reaction of hydrolysis and the reaction of decarboxylation were measured for annual ratio of corrosion by following the procedure of Example 1, the ratio was found to be 0.03 mm/year.

EXAMPLES 3 to 8

The hydrolysis and decarboxylation and the azeotropic distillation were performed by following the procedure of Example 1 while changing the concentrations of sulfuric acid, the reaction temperatures, and the duration of reaction in the former step reactions and the latter step reactions as shown in Table 1. The conversion ratio of the raw material (4-amino-2,3,5,6-tetrafluorobenzonitrile), the amount of TFA (2,3,5,6-tetrafluoroaniline) formed (mol %), the presence or absence of corrosion on the reaction vessels used for the reaction of analysis and the reaction of decarboxylation, the yields (yields at the steps of hydrolysis and decarboxylation), and the annual ratio of corrosion were as shown in Table 1. The results of Examples 1 and 2 are collectively shown in the table 1.

TABLE 1

Example	Former step reactions					Former step reactions					Annual corrosion ratio (mm/year)
	Temp. (° C.)	Conc. of H ₂ SO ₄ (%)	Duration (hr)	conversion ratio (mol %)	Amount of TFA (mol %)	Temp. (° C.)	Conc. of H ₂ SO ₄ (%)	Duration (hr)	Yield of TFA (mol %)	Corrosion (determined)	
1	110	90	15	100	20	110	80	15	98	none	0.02
2	100	90	15	98	8	120	80	15	98	none	0.03
3	90	95	17	95	7	110	80	16	97	none	0.01
4	100	90	18	100	8	120	90	14	98	none	0.03
5	120	90	13	100	31	120	80	8	97	none	0.05
6	110	85	16	100	25	120	85	10	99	none	0.04
7	80	95	12	90	3	120	85	20	98	none	0.02
8	70	95	15	85	2	110	80	21	97	none	0.01
Comparative Example 1	140	60	6	96	82.5	—	—	—	—	found	0.30

separating tube was charged with 300 ml of water and heated to 100° C., with the water as kept stirred, to retain a state of reflux in the flask.

EXAMPLE 9

(Step of Hydrolysis and Decarboxylation)

A 200 ml four-neck flask provided with a stirrer, a thermometer, and a cooling tube was charged with 120 g of

an aqueous 85% sulfuric acid solution, heated to 130° C., and then after retained at this temperature. Into the flask, 10 g of the 4-amino-2,3,5,6-tetrafluorobenzonitrile (94% in purity) obtained in Referential Example 1 was added in a molten state dropwise at a rate of 4 g/hr over a period of 10 hours. After the dropwise addition was completed, the reaction was further continued for eight hours. When the reaction solution obtained at the end of the reaction was analyzed by liquid chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was found to be 100% and the yield of the target product, 2,3,5,6-tetrafluoroaniline, was found to be 98%.

(Step of Azeotropy)

In a 200 ml four-neck flask provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube, 50 g of water was placed, heated to 100° C., and retained at this temperature. Then, the reaction solution obtained at the steps mentioned above was transferred into the dropping funnel adapted to retain temperature by heating and dropped therefrom at a rate of 1.20 g/hr. The temperature of heating in the reaction vessel was continuously elevated so as to expel the target product, 2,3,5,6-tetrafluoroaniline by distillation into the water separating tube at 100° C. during the initial stage of the distillation and at 140° C. at the time of completion of the distillation. The 2,3,5,6-tetrafluoroaniline expelled by distillation was withdrawn into a receptacle and the water formed by distillation was returned to the four-neck flask. Thus the expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours. As a result, 32 g of 2,3,5,6-tetrafluoroaniline having a purity of 98.5% was obtained. The yield was 98.5%.

When the inner walls of the reaction vessels used for the hydrolysis and the decarboxylation and for the azeotropic distillation were visually inspected, no discernible sign of corrosion was detected on any of the reaction vessels. When the reaction vessels used for the hydrolysis and the decarboxylation were measured for annual ratio of corrosion, the ratio was found to be 0.09 mm/year.

Comparative Example 1

2,3,5,6-Tetrafluoroaniline was produced from 4-amino-2,3,5,6-tetrafluorobenzonitrile. To be specific, in a 200 ml four-neck flask provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube, 100 g of 60% sulfuric acid was placed and heated to 140° C. To the hot sulfuric acid, 36 g of the raw material, 4-amino-2,3,5,6-tetrafluorobenzonitrile (having a purity of 94% and containing 6% of 2-amino-3,4,5,6-tetrafluorobenzonitrile as an impurity) was added dropwise at a rate of 6 g/hr. The 2,3,5,6-tetrafluoroaniline which was formed by the reaction was expelled by azeotropy with water, guided into the water dropping tube, and separated from the water. The reaction was continued for six hours while the reaction vessel was supplied with the same amount of water as expelled by distillation. After the completion of the reaction, the conversion ratio of the raw material determined by gas chromatography was found to be 96 mol %. When the 2,3,5,6-tetrafluoroaniline expelled by distillation was analyzed, the purity was found to be 95.3% and the yield to be 82.5%.

When the reaction vessels were visually inspected, the inner walls thereof were found to sustain a discernible corrosion probably induced by hydrogen fluoride. The annual ratio of corrosion was 0.3 mm/year.

EXAMPLE 10

(Step of Hydrolysis)

In a 100 ml four-neck flask provided with a stirrer, a thermometer, and a cooling tube, 14.7 g of the solid (having

a 4-amino-2,3,5,6-tetrafluorobenzonitrile content of 94%) obtained in Referential Example 1 was placed and 80 g of an aqueous 10% sodium hydroxide solution was further added thereto and they were allowed to react at 50° C. for eight hours. When the reaction solution obtained at the end of the reaction was analyzed by gas chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzonitrile was found to be 100% and the yield of the target compound, 4-amino-2,3,5,6-tetrafluorobenzoic acid, was found to be 98%.

(Step of Decarboxylation)

A 100 ml autoclave was charged with the reaction solution obtained in the step of hydrolysis plus 9.8 g of concentrated sulfuric acid (equivalent to the sodium hydroxide used in the step of hydrolysis). With the inner temperature of the autoclave elevated to 130° C. and the inner pressure of the reaction vessel retained at 0.2 MPa, the reaction was carried out for eight hours. When the reaction solution obtained after the completion of the reaction was analyzed by gas chromatography, the conversion ratio of 4-amino-2,3,5,6-tetrafluorobenzoic acid was found to be 100% and the yield of 2,3,5,6-tetrafluoroaniline was found to be 95%.

(Step of Azeotropy)

In a 200 ml four-neck flask provided with a stirrer, a thermometer, a dropping funnel, and a water separating tube, the reaction solution obtained in the step of decarboxylation was placed, heated to 100° C. and retained at this temperature. With the water placed in the dropping funnel added dropwise thereto, the temperature of the heating of the flask was elevated so as to expel the target compound, 2,3,5,6-tetrafluoroaniline by distillation into the water separation tube. The expulsion of 2,3,5,6-tetrafluoroaniline by distillation was attained at 100° C. in a reaction vessel during the initial stage of distillation and at 140° C. at the time of completing the distillation.

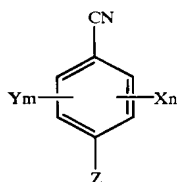
With the distilled 2,3,5,6-tetrafluoroaniline withdrawn into a receptacle and the distilled water returned to the four-neck flask, the expulsion of 2,3,5,6-tetrafluoroaniline by distillation was continued for three hours. As a result, 11.3 g of 2,3,5,6-tetrafluoroaniline having a purity of 98.5% was obtained.

The total yield in the step of hydrolysis and decarboxylation and in the step of azeotropy was 94.5%. When the interiors of the reaction vessels used for the hydrolysis and the decarboxylation and for the azeotropy were visually inspected, no discernible sign of corrosion was detected in any of the reaction vessels. The annual ratio of corrosion of the reaction vessels used for the step of hydrolysis and decarboxylation was 0.02 mm/year.

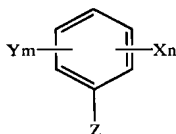
What is claimed is:

1. In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the reactions of hydrolysis and decarboxylation in multiple steps

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(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{—N(R}^1\text{)(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$)



(wherein the symbols have the same meanings as in the general formula (1).

2. A method according to claim 1, wherein the conversion ratio of the aromatic cyano compound represented by the general formula (1) is fixed at a level of not less than 40 mol % and the molar ratio of the formation of the aromatic compound represented by the general formula (2) to the initial amount of the aromatic cyano compound represented by the formula (1) is fixed at a level of not more than 80 mol % in a former step reaction in said multiple steps respectively, and subsequently the reactions of hydrolysis and decarboxylation are terminated in and after a latter step reactions in said multiple steps.

3. A method according to claim 1, wherein the reactions in the former step and the latter step in said multiple steps are carried out on the conditions of lowering the concentration of said acidic substance and/or increasing the reaction temperature.

4. A method according to claim 3, wherein said acidic substance is an aqueous sulfuric acid solution.

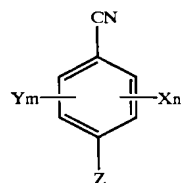
5. A method according to claim 1, wherein said aromatic cyano compound is 4-amino-2,3,5,6-tetrahalogenobenzonitrile and said aromatic compound is 2,3,5,6-tetrahalogenoaniline.

6. A method according to claim 1, wherein said reactions of hydrolysis and decarboxylation are carried out in the presence of sulfuric acid in a reaction vessel made of glass or lined with glass.

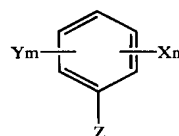
7. A method for the production of an aromatic compound, characterized by forming an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an aqueous medium and subsequently recovering the obtained aromatic

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compound from the reaction solution by azeotropic distillation with water



(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen-containing group represented by $\text{—N(R}^1\text{)(R}^2\text{)}$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of $1 \leq m+n \leq 4$)



(wherein the symbols have the same meanings as in the general formula (1).

8. A method according to claim 7, wherein said aqueous medium contains an acidic substance and the concentration of the acidic substance in said aqueous medium is in the range of 80 to 98 weight %.

9. A method according to claim 8, wherein said acidic substance is sulfuric acid.

10. A method according to claim 7, wherein the molar ratio of the formation of the aromatic compound represented by the general formula (2) is not less than 85 mol % to the initial amount of the aromatic cyano compound represented by the general formula (1).

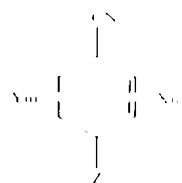
11. A method according to claim 7, wherein said aromatic cyano compound is 4-amino-2,3,5,6-tetrahalogenobenzonitrile and said aromatic compound is 2,3,5,6-tetrahalogenoaniline.

12. A method according to claim 7, wherein said aqueous medium contains an alkaline substance.

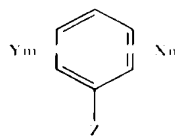
13. A method according to claim 7, wherein said aromatic cyano compound is 4-amino-2,3,5,6-tetrafluorobenzonitrile and said aromatic compound is 2,3,5,6-tetrafluoroaniline.

14. In the production of an aromatic compound represented by the general formula (2) by hydrolyzing and decarboxylating an aromatic cyano compound represented by the general formula (1) in the presence of an acidic substance, a method for the production of the aromatic compound, characterized by performing the hydrolysis and decarboxylation in multiple steps and effecting the recovery of the formed aromatic compound from the reaction solution by azeotropic distillation with water

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(wherein X is a halogen atom, Y is a cyano group, nitro group, or carboxyl group, Z is a nitrogen containing group represented by $-\text{N}(\text{R}^1)(\text{R}^2)$ (wherein R^1 and R^2 are identical or not identical substitutes superposed on a nitrogen atom and selected from among hydrogen atom and linear or branched alkyl groups of 1 to 4 carbon atoms), m is 0, 1, or 2, and n is 1, 2, 3, or 4, providing that the sum of m and n falls in the range of 1 to m+n=4)



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(wherein the symbols have the same meanings as in the general formula (1))

15 A method according to claim 14, wherein a former step reaction in said multiple steps are carried out under the condition of an acidic state in a concentration in the range of 80 to 98 weight % to react an aromatic cyano compound represented by the general formula (1) and subsequently a latter step reactions in said multiple steps are carried out under the condition of having the concentration of said acidic substance lowered by a level in the range of 5 to 50 weight % and/or elevating the reaction temperature by a level in the range of 5 to 30° C.

16 A method according to claim 14, wherein the molar ratio of the formation of the aromatic compound represented by the formula (2) to the aromatic cyano compound represented by the formula (1) in said reaction solution is not less than 85 mol %.

17 A method according to claim 14, wherein said acidic substance is an aqueous sulfuric acid solution.

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